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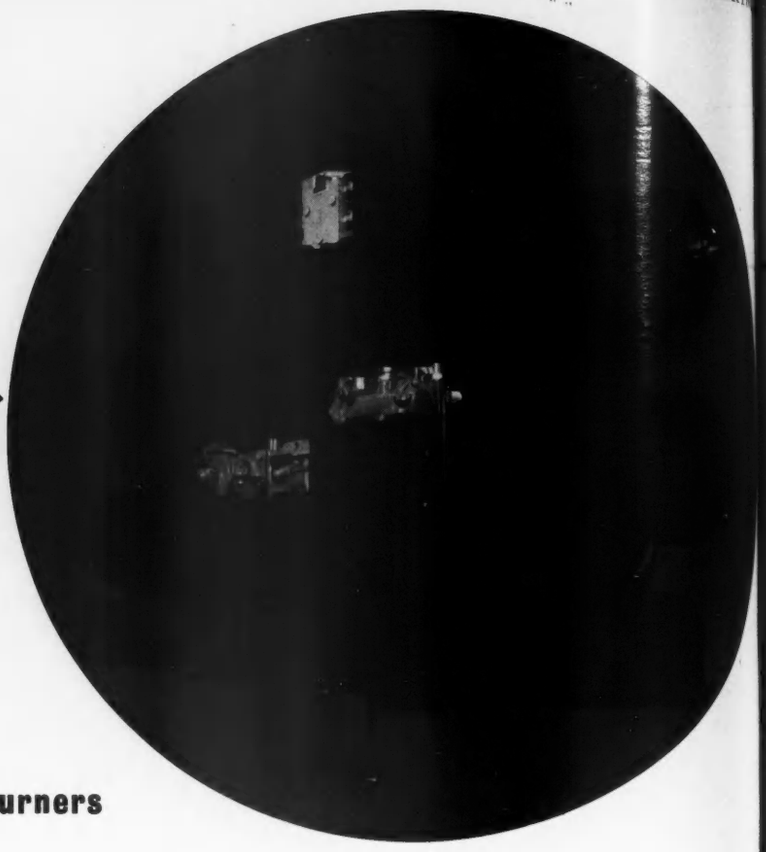

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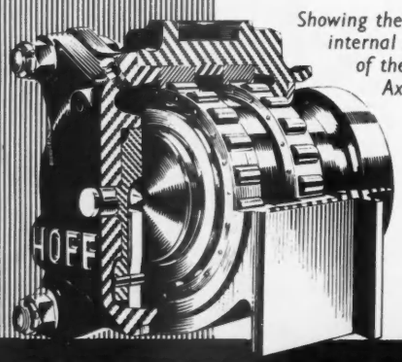

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ENGINEERING

PUBLISHED EVERY FRIDAY

Vol. 187 No. 4856 3 April 1959

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Harnessing the Bulge

FOR the past eight or nine years, what has come to be called the "bulge" has been passing through the schools like a rabbit through a snake. Now the bulge with its attendant problems is beginning to reach industry, as the babies born between 1942 and 1950 over and above the normal population increase come on to the labour market. The total of these bulge babies has been put at 900,000, of which about half are boys. Of the boys going into industry straight from school, 7 per cent take commercial and clerical jobs, 36 per cent enter apprenticeship, 56 per cent become semi-skilled or unskilled workers, and the odd 1 per cent take up professional work. If these same proportions hold good when the bulge reaches industry a number of problems will arise. Clearly too many of those seeking jobs will be going into the ranks of the semi-skilled or unskilled. Is this state of affairs inevitable or can some better way be found of utilising the young entry?

This very broadly is a question reviewed not long since in the Carr Report and has now been examined in a recently published pamphlet by Mr. John Wellens, an industrial training consultant (*The Bulge: Its Industrial Impact*, 5*s* post free from the John Wellens Organisation, 24 Mossley Road, Grasscroft, Nr. Oldham). One result of the Carr Report was the establishment of the Industrial Training Council to advise employers on what to do about the many boys who are capable of becoming craftsmen but who, for want of training facilities, drift into the ranks of the unskilled. Mr. Wellens has some very shrewd observations to make about the council and its technique of peaceful persuasion. The deciding factor in determining whether a particular firm will take on more apprentices is the state of its own order books, not of the local school registers. This means that in slack times only the best of the boys entering industry, usually those with O-Level General Certificate of Education, become apprentices. The engineering industries do, of course, account for a major proportion of the total apprenticeship intake.

But while some boys have been chosen, many others, especially in the past year, have been left. It is this large group of "juveniles of low intelligence, poor attainment and meagre ability" who are the hard core of the problem. Is there nothing else that can be done for them except trying to induce firms to make apprentices of them when the firms themselves are unable to accept an abnormally high intake?

Mr. Wellens thinks that part of the trouble is that many boys move out of apprenticeship into jobs above the craft level before their time is out. If these potential draughtsmen, engineers, scientists and so on, could be selected before they got into the apprenticeship stream then fewer places would be wasted.

This is the sort of problem that will never be solved by exhortation. Certain necessary policy measures must be taken. The question is by whom? At the present the bulge babies are on industry's doorstep and neither the employers nor the trade unions show any great inclination to take them in. Mr. Wellens proposes a national industrial training agency which would be a full-time body covering the whole field of "management, supervision, apprenticeship for skilled crafts, technical and technological studies, training of semi-skilled operatives, technical college courses and university study." It would "gather and disseminate information" and maintain a clearing house for higher grade industrial courses and advanced apprenticeships including Dip.Tech. courses, sandwich courses and commercial apprenticeships. A schools appointments bureau for the state schools on the lines of the Public Schools Appointments Bureau would be another of its activities. In fact, the agency would be a clearing house to which employers, trade unions, the schools, local authorities and the Ministry of Labour could turn for information or help.

Clearly there would be many problems to be resolved before a scheme of this sort could be put into operation. The relationship of existing bodies such as the Youth Employment Service to the proposed agency is just one example of them. But although there would be difficulties in implementing Mr. Wellens' suggestions, they have the great merit of looking at the problem as a whole. The need to improve our training methods was underlined earlier this month by the report of the Advisory Committee on Further Education in Commerce. British commercial education compares very badly with what is being done on the Continent, especially in Germany.

It is to be hoped that the sharp shock administered by this report and Mr. Wellens' pamphlet will start public discussion on what is undoubtedly one of the vital questions of the day. To regard the bulge with misgivings is to miss an opportunity. As Mr. Wellens observes, it should not be the purpose of any campaign to fight the bulge, but to harness it.

Cover Picture.—*Racing cars provide a unique opportunity for proving materials, design and construction techniques. Every detail counts. The magnesium wheels, shown in the cover picture being fitted, cut the unsprung weight, and tubular construction is efficient in obtaining structural strength without the use of heavy sections.*

Plain Words

I was glad to read the other day a report that Dr. Barnes Wallis, chief of aeronautical research and development to Vickers-Armstrongs (Aircraft) Limited, does not like to be called a "scientist." He prefers "engineer." It seems to me that he is right to make the distinction, especially now that the word scientist has a certain glamour.

Fundamentally, of course, the position is no different today than it was years ago. Engineers are often in advance of science in the sense that they successfully harness phenomena which are only imperfectly understood; and science often produces data and laws which are known for years before engineers find a way to put them to practical use. Furthermore, engineers sometimes contribute to scientific discovery, and scientists to practical production. But the accepted distinction holds in nine cases out of ten: science is study, the acquisition of knowledge, the postulating of significant relationships—in short, understanding; engineering is designing, manufacturing, producing and constructing.

Of course, each is more than these rather loose definitions. I find my thoughts are clarified if I think of a spectrum, at one end of which is pure science, and at the other the selling of a product to a customer. Engineering, as I interpret it, reaches nearly to both ends of the spectrum. Indeed, it is the engineer (or a scientist acting in the capacity of an engineer) who is best able to take the whole view; who can relate what people want to what a scientific approach may be expected to yield.

I find that there is a regrettable tendency for institutions to speak of "the science of such-and-such engineering" when they might just as well say "the art of such-and-such engineering"—or better still, just say "such-and-such engineering." You cannot practise engineering without using scientific methods, nor without using art.

I am not arguing that one is "better" than the other. All such arguments are futile; they remind me of those speakers who, wishing to emphasise the indispensible nature of their trade or profession (or their products), imagine that they have scored a direct hit when they tell us that civilisation as we know it would cease to exist without their trade . . . This is true today of practically all trades and professions.

For an engineer, his proudest moment is when he sees his great design before him, completed and functioning perfectly. For the scientist, if he is lucky, it is the arrival of some new conception, the product of his brain, which will extend man's understanding. Thank heaven that they can sometimes share each other's joy. But there is no need to blur the distinction.

CAPRICORN

Weekly Survey

Power from Snowy Mountains

The first underground power station in the Snowy Mountains hydroelectric and irrigation scheme in South Eastern Australia is expected to go into production this month. The scheme, which is half way between Melbourne and Sydney, was described in detail in ENGINEERING in 1956 (vol. 182, pp. 232, 394, 540, 630, 661). The underground power station now being commissioned is located down stream from the Tumut Pond Dam, which was completed in September last. The power station is expected to reach its full capacity of 320 MW before next October, some eight months ahead of schedule.

The Snowy project when completed will have an output of 3 million kW and will have cost more than £A400 million. Seven major dams are involved, 15 power stations and over 80 miles of tunnels. The Snowy Mountains are at the southern end of one of the few areas in Australia having an annual rainfall in excess of 30 in. Rain falling on the eastern side of the Snowy Mountains is drained by the Snowy River and its tributaries which flow to the south eastern coast of Victoria through an area of good rainfall and apart from the generation of electricity, the project was designed to divert much of this water to the western side of the watershed where it can be used to irrigate some 600,000 acres of dry land bordering the Murray and Murrumbidgee rivers, thus increasing the irrigated land in Australia by more than a third and the output of food by more than £A30 million. The full scheme was expected to take 25 years to complete.

Cables and Highways

Plans for major improvements in the country's communications have recently been announced. The Post Office will spend £1½ million on a new cable ship of 4,000 tons to supplement the cable laying work being done by the Monarch (8,000 tons). The primary purpose of the new ship will be to maintain existing and projected large capacity cable across the Atlantic. The keel will be laid early next year and delivery is expected before the end of 1961.

The White Paper on Post Office capital expenditure 1959-60, which referred to the new cable ship also gave details of a new cable between Scotland and Newfoundland, the first ocean link in the 30,000 mile Commonwealth round-the-world network which is expected to cost £88 million. The new cable, which is to be laid in 1961, will provide 60 speech circuits and will cost £3 million (the bulk of the United Kingdom expenditure will be borne by Cable and Wireless). Another submarine cable project is between Britain and Sweden. The Post Office are to spend £90 million in 1959-60 (£92 million in 1958-59) on capital projects, mainly on telephone connections and on inland telegraph facilities. The total of exchange connections for business may rise by 30,000 to 1·83 million and residential connections by 110,000 to 2·77 million. The number of applications for telephone service in March, 1960, is expected to be about 137,000, 9,000 less than this year and 46,000 less than in March, 1958.

Expenditure on roads will rise to £140 million a year. Mr. Watkinson, Minister of Transport, pointed out that expenditure this year would be nearly £47 million from central funds on new construction and major improvements (spending averaged £12 million over the past four years). In addition, some £33 million of Government money will be spent on maintenance and minor improvements and £50 million will be contributed by local authorities. The major items on the programme are the second half of the Maidstone bypass (due to start in April); the Maidenhead bypass and a bridge over the Thames (May); work on viaducts of the Birmingham-Preston motorway (May or June); Doncaster bypass (early summer); Staines bypass, work on Stamford and Stevenage bypass and Great North Road, all due to start this summer.

Budgetary Prompting

There has been a certain amount of discussion about the likelihood of the Chancellor of the Exchequer taking sixpence off the income tax in this year's budget. Such would represent a concession of the order of less than £200 million. The *National Institute Economic Review*, the second number of which was issued at the end of last month, considers that concessions on this scale are not big enough to stimulate the economy sufficiently.

In the opinion of the Institute, even if such an income tax reduction were reinforced by slight cuts in purchase tax and some incentive to investment, the effect on industrial output would be modest. Over one-quarter of the concessions would go into extra savings and additional imports. The indirect effects of the extra spending would be multiplied in time but this would happen only gradually with no widespread pressure on industrial capacity and labour resources. The Institute admits that a bold expansionist policy may be a strain on the balance of payments, which is already less favourable than a year ago, but it thinks that one of the major industrial countries must promote expansion more vigorously to develop world trade, especially from the primary producing areas.

The Institute considers that the recovery through the past winter has been brought about by substantial consumer spending and that this is going to peter out shortly. The present incentives to invest in manufacturing industry are too weak, and confidence in the renewal of general economic expansion is needed to maintain private investment. Meanwhile public investment, notably in basic industry, should be encouraged.

British Electrical Exports

Concern has been expressed about the sluggish performance of British electrical engineering exports. Mr. J. D. Knowles, the retiring chairman of the British Electrical and Allied Manufacturers' Association, said at the association's annual meeting that particular concern was felt about the entry into Indian and Middle East markets of East European electrical goods manufacturers, backed by Soviet loans. Germany was not expected to be as serious a competitor this year in the export market as formerly. German manufacturers are also worried about the Communist threat and meetings of European engineering concerns have been held in Paris to discuss the problem.

The big drop last year was in cables and domestic equipment. Categories to show increases were generating sets, transformers and electrical vehicles. According to the export indices of the Board of Trade, the exports of electrical machinery, apparatus and appliances last year at 123 (1954 as 100) compared with 127 in 1957. This was a fall of 3 per cent. The drop in engineering exports as a whole was just under 2 per cent. Other resilient items were vehicles and aircraft, shipped mainly to the United States market.

It has been apparent for some time that export prospects for all engineering products this year depended on buoyancy of the United States market, the impact of the European Common Market and political developments in the Middle East. So far this year, the American market has

been satisfactory while the effect of the European Common Market remains obscure. In the Middle East, which is the area that has drawn comment from Mr. Knowles, the situation has become more unstable. Soviet economic aid to Iraq on a significant scale is bound to affect adversely the prospects of the exports there.

World Steel in 1958

Last year world crude steel output at 270 million tons was the same as in 1955. But in the meantime it had climbed to 293 million tons in 1957 and come down again. Nearly all the world's steel-making countries except the East European satellites and China saw their production fall. These facts are given in the *Quarterly Bulletin of Steel Statistics for Europe*, published by the Economic Commission for Europe. The biggest plunge was taken by United States crude steel production. From the 1955 boom year peak of 105 million tons down it went to 77 million tons. The change in most Western European countries was in the same direction, but at a much slower rate. For the six-nation European Coal and Steel Community the drop was only 4 per cent. In the United Kingdom output fell 10 per cent to 20 million tons.

On the other side of the Iron Curtain exactly the opposite trend was seen. In the USSR production rose from 51 to 55 million tons. But the biggest efforts were made by China, which came up to seventh place among world steel producers with an output of 11 million tons. Some of this is produced in primitive furnaces under backyard conditions. However, the fact that output two years before was less than half its 1958 level, makes China's performance spectacular by any standards. The ending of the recession in the United States has seen an upturn in steel and with industry rebuilding its stocks an output of between 90 and 100 million tons is forecast for this year. In Britain, the trend was also upwards at the end of last year, but at a fairly modest incline. It looks as though anything sharper will have to wait for the general speeding up of business activity that the Minister of Labour seems to think is on the way.

Sites for Power Stations

The Central Electricity Generating Board propose to examine the suitability of five areas in the East Midlands as sites for coal-fired power stations. Ground surveys and trial borings are being carried out at Ratcliffe-on-Soar, Holme Pierrepont, Market Warsop, Cottam and West Burton.

The East Midlands coalfield is the largest producer in this country of low-grade coal for electricity generation. Coal-fired power stations already at work or planned near the East Midlands coalfields include Drakelow A, B and C stations (ultimate capacity 2,220 MW), Willington A and B stations (800 MW), Castle Donington (600 MW), Staythorpe A and B stations (720 MW) and High Marnham (1,000 MW).

The proposal for an additional station is to absorb future coal production close to the pits and help to keep pace with the growing demand for electricity, both locally and elsewhere. The generating capacity of the station will depend upon the facilities available at the various sites being investigated but it may exceed one million kW corresponding to a coal consumption of about three million tons a year. These plans are only tentative at the moment since approval will have to be given by the Ministry of Power. The CEGB have also announced surveys of further sites for nuclear power stations, to which reference is made in Atomic Review.

Counting Computers

United States industry becomes ever more computer conscious: 624 general-purpose electronic computers were installed in the last nine months of 1958. This represents approximately a 45 per cent increase over the total reported last March. The very large sizes showed an increase of 30 per cent. The figures were produced by the research staff of John Diebold and Associates, Incorporated, the New York management consulting firm which specialises in computer applications and automation in industry and carries out an annual computer census.

If all types of computers are counted—large, medium and small, and including electronic card computers—the total number in use is 7,200 compared to 6,000 last March. Since the last census, three manufacturers have announced new computer systems: IBM's 7070, Remington Rand's new Univac and RCA's 501. In addition, many new components and features have been made available for existing systems.

Diebold's census shows that there are seven makers of large-scale general-purpose digital computer systems (machine magnetic tapes and operating at millisecond arithmetic speeds): Burroughs, Datamatic, National Cash Register and Philco, in addition to the three major firms mentioned above. IBM and Remington Rand dominate the field, with 62 and 30 per cent respectively of total deliveries. The same two firms also dominate the market for medium scale (magnetic tapes and millisecond speeds) and small scale (no magnetic tapes, internally programmed) machines. Alwac, Bendix and Underwood are additional firms in the medium-scale field and Monroe Calculating Machine, J. B. Rea and Royal McBee in the small-scale market. Competition is tough and IBM are increasingly strong, accounting for over three-quarters of all machines produced.

Aircraft Engineers

Two notable contributors to the growth of the British aircraft industry have died recently, Mr. L. W. Warner, F.R.Ae.S., director-general of aircraft production at the Ministry of Aircraft Production during the Second World War, and Mr. J. L. P. Brodie, M.I.Mech.E., F.R.Ae.S., engineering director of the de Havilland Engine Company Limited.

Leonard William Warner, who was 73 at the time of his death on Friday, 20 March, was one of the pioneers of the aircraft industry. He joined Short Brothers at the Isle of Sheppey in 1909 as an experimental engineer and stayed with them until 1914, when he joined the Aeronautical Inspection Department as an inspector. He was progressively promoted to chief inspector in 1928. In 1939 he left the AID to become assistant director of production responsible for the production of bombers, and rose to be director-general of aircraft production.

John Longmuir Penman Brodie, who was 59 when he died suddenly at Putney Hospital on Monday, 23 March, entered aviation during his apprenticeship with Arrol-Johnston Limited in Dumfries, 1914-1919, when he worked on the design of the 230 h.p. Beardmore-Halford-Pullinger engine which went into production as the Siddeley Puma, of which some 6,000 were built and powered the de Havilland and other combat aircraft. In 1923 he joined Mr Frank Halford when the latter set up a design business in London. In 1925 Halford renewed his wartime association with the de Havilland company, and from then on, until the Second World War, all the efforts of the Halford-Brodie team were directed to satisfying de Havilland's civil requirements. In 1926 de Havilland decided to build their own engines at Stag Lane, to Halford's designs, and thus began the great family of Gipsy engines, with every one of which Brodie was concerned during more than three decades.

While still assistant chief designer to Halford, Brodie took over in 1940 the administration of the de Havilland Merlin repair department and the following year he assumed the engineering management of the de Havilland engine and propeller divisions. He was concerned with the development of the Goblin jet engine and the Ghost, which started life as a military engine, and later the de Havilland rocket engines.

Letters to the Editor

MANCUR SPRING BALANCE

SIR, Your correspondent, Mr. J. F. Perrin, writing in your issue of 20 March, has recalled a question that, for many years, has puzzled those interested in the history of weighing devices; that is, the origin of the name " Mancur " by which an old C type spring balance was known.

Large numbers of these balances, of which a typical specimen is shown in the attached illustration, were made in the United States and in Europe during the latter half of the 19th century. They featured in the 1886 catalogue of a well-known English firm of spring balance makers, George Salter and Company Limited.

They were used principally by farmers and were very convenient for their purpose, always being constructed to weigh in two ranges of capacity. But, compared with modern equipment, they were crude and insensitive and would not satisfy our present weights and measures regulations.

Inquiries we have made have failed to establish how the name " Mancur " became associated with the device or to trace its country of origin.

I am hoping that this correspondence will be seen by your American readers, amongst whom there may be someone who can communicate authentic information, which we should welcome to enable our historical records to be completed.

Yours faithfully,
L. SANDERS.

W. & T. Avery Limited,
Soho Foundry, Birmingham.
20 March, 1959.

FLAME PLATING

SIR, We are very interested to read the article appearing on page 59 of your issue of 9 January, entitled " Flame-Plating Improves Aluminium Pulleys for Wiredrawing." We notice in the last paragraph of the article that additional information may be obtained by contacting the Linde Department, Union Carbide International Company, 30 East 42nd Street, New York 17, USA.

For your information we would like to advise that we are the sole licensees in the United Kingdom for this process, and all information emanating from this country should be dealt with at Warwick where the plant is now in operation.

Yours faithfully,
H. F. HAYCOCK,
Sales Manager.

John Harris Tools Limited,
PO Box 33, Warwick.
25 March, 1959.

ENGINEERING'S INDEX

The Index to Volume 186 of ENGINEERING (July-December, 1958) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher, 36 Bedford Street, London, WC2. Any reader wishing to receive regular copies of the Index as they are published can apply to be put on the mailing list.

Plant and Equipment

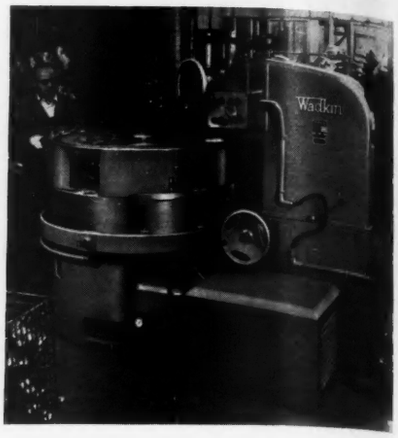
CONTINUOUS ROTARY MILLER

Continuous rotary milling machines are now being made by Wadkin Limited, Green Lane Works, Leicester. The machines comprise a substantial cast iron base which carries the 48 in diameter rotary table and also the main frame carrying the 6 h.p. type LH2 high-speed vertical milling head.

This high speed head unit has four speeds of 6,000, 4,000, 3,000 and 2,000 r.p.m., obtained by means of a two-speed motor and two-step pulley. Belt tensioning and adjustment are built into the head and the whole unit is totally enclosed within the main head frame. The high-speed head is mounted on precision slides incorporating a 12 in vertical adjustment and fast and slow feed handwheels are provided, the former for quick adjustment vertically and the latter for fine setting. The head is counter-balanced to give easy movement in a vertical plane, and 12 in horizontal adjustment is also provided in order to track the cutter head accurately on the rotary table. Hand locks are provided to both vertical and horizontal slides.

The table is arranged for three selective speeds controlled through a change speed lever on the feed gearbox, giving 1 r.p.m., $\frac{3}{4}$ r.p.m. and $\frac{1}{2}$ r.p.m., corresponding to peripheral feeds of 150 in per min, 100 in per min and 50 in per min respectively.

All the fixtures on the tables are air operated, air being fed up under pressure through the centre of the table. The fixtures which were designed and built by Wadkin Limited incorporate air clamps which are operated automatically during the table cycle. These air clamps are actuated by a cam bar on the machine and come into action just prior to the component passing under the cutter track and are released automatically as soon as the component has been machined. Loading is therefore reduced to dropping the components into the apertures provided on the fixtures and lifting them clear when machining has been completed.

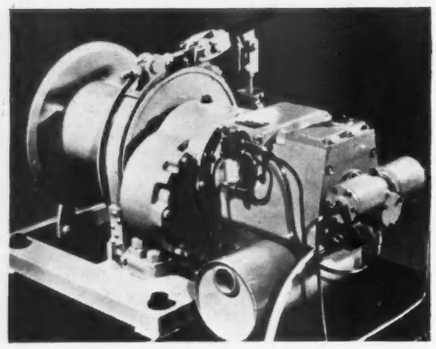


Continuous rotary milling machine, with table guards in place.

Two safety measures are incorporated: first, the component is subjected to downward pressure by a rubber roller to ensure correct seating in the fixture, and second, a trip flap is fitted which instantly stops the table rotation as soon as it is deflected by an insecurely seated component. Under normal operating conditions the whole of the fixtures are protected by circular guards.

REMOTE CONTROL FOR AIR MOTORS

To the complete range of Holman Rotomotors, which now comprises eleven sizes with powers from 0·75 to 16 b.h.p., has been added control, equipment manufactured by Maxam Power Limited, one of the Holman group of companies. This equipment, an example of which is shown in the accompanying illustration, controls the forward and reverse operation, in addition to actuating a cylinder-operated brake on hoists, winches, etc. The lever controls can be conveniently located on a panel at distances up to 200 ft from the Rotomotors.



Remote control fitting for air motor.

The remote control equipment for each Rotomotor unit comprises a hand-operated lever valve situated on the control panel and, on the motor, a rack, actuated by duplex pistons situated at each end, which engages a pinion on the reversing valve. In the neutral position compressed air is applied to both ends of the duplex pistons, and the reversing valve shuts off the air supply to the vanes of the rotor. When the lever is depressed for forward or reverse positions, pressure is released from one side of the duplex piston and the rack moves across thus turning the reversing valve and allowing air to pass to the vanes of the rotor. An emergency stop valve can be placed in circuit in front of the control valve.

The reversing control valve can be either a single lever-operated valve or two-push button types which automatically assume neutral upon release. A lever control valve can be fitted which also reverts to neutral upon release. Limit switches can be placed between load and motor to limit movement and prevent over-run in either direction. Provision is made on the motor for a valve to control the supply of air to a spring operated air release brake cylinder when required.

Where very fine control or inching is necessary, a Maxam slow lowering control valve is supplied. This valve works directly on the brake cylinder and thereby permits the operator to set down the load accurately and carefully to the desired position.

Control valves are made in two sizes, $\frac{1}{16}$ in for pipe lengths up to 40 ft from control to motor, and $\frac{1}{2}$ in for distances greater. The Rotomotor units may be ganged in pairs on to a common gearbox and remotely controlled as one unit, and can also be traversed for left and right movement on air motor driven travelling mounting.

DISC SLIDE RULE

A simple circular slide rule has been produced by the General Industrial Company, 5738 North Elston Avenue, Chicago 30, Ill., USA. With an overall diameter of less than $4\frac{1}{4}$ in it is approximately equivalent to a straight rule of 11 in. There are only the two scales, inner and outer, printed round the edges of two concentric discs, and the cursor enabling simple multiplication and division operations to be carried out. The rule can be obtained from the above address at a price of 8*s* or its equivalent in International Postal Coupons.

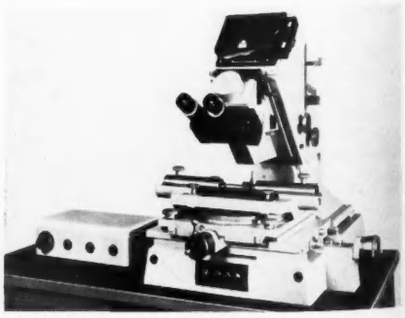
FLAMEPROOF VIBRATORS

Flameproof models have now been added to the range of rotary vibrators made by the Blending Machine Company Limited, Bond Street, Birmingham, 19. Buxton Certificate FLP4107 covers the flameproof machines, which are available in five size ratings, 80, 160, 250, 500 and 800 W. The fixing centres of the flameproof and non-certified models are identical.

MEASURING MICROSCOPE

The toolmaker's large measuring microscope shown in the illustration is one of the range made by Carl Zeiss and available in this country from Degenhardt and Company Limited, 6 Cavendish Square, London, W1. It has a measuring range of 6 in by 3 in, using gauge block switching. Drum divisions are to 0·0002 in and angles can be measured to 1 minute of arc.

The instrument has three basic systems of measurement. The first is with an optical feeler using shadow image, contact feeler or shadow-double image for checking symmetry. The second employs a mechanical feeler and double image, and the third is an optical image in conjunction with a standard reticle. Equipment also includes a projection attachment for direct comparison with drawings; a ground glass projection screen and a photographic recorder. There are also alternative methods of illumination. The optical system gives magnifications up to 80.



Toolmaker's measuring microscope with illumination and projection control.

ELECTRONIC COMPONENTS

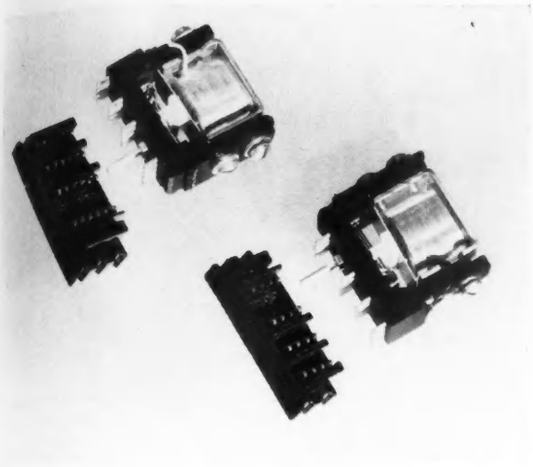


Fig. 1.

Wire Contact Relay

THREE electronic components have now been put on the market by the Woden Transformer Company Limited, Moxley Road, Bilston, Staffordshire, and T. S. Precision Engineering Limited. Two, the wire contact relay and the patchboard, are new, and the third, the torque motor, is now available for industry.

The wire relays, shown in Fig. 1, have been introduced to meet the need for a high speed multi-pole relay in computer and general control engineering fields. In basic form it is a plug-in relay designed for use in individual or multi-holders which can be soldered directly or used with a quick release plug.

The basic unit is a 4-pole change-over relay with twin wire moving contacts which are readily interchangeable. The unit and all fixed contacts are in a single piece moulding of high dielectric strength material. All fixed contacts are of silver alloy. The design of the relay is such that high speed operation is obtainable with operating and release times down to 3 milliseconds.

The unit has an expected contact life of 3,000,000 operations and the range of contact life can be considerably extended by the use of quenching circuits or by operating at lower ratings. Models are available with coil resistances from 100 to 10,000 ohms and in operating voltages from 6 to 150 volts d.c.

The standard 4-pole unit measures approximately $1\frac{3}{4}$ in by $\frac{5}{8}$ in by $1\frac{1}{2}$ in overall. 6 and 12-pole units are also available, dimensions of the 6-pole unit being $1\frac{3}{4}$ in by $\frac{7}{8}$ in by $1\frac{3}{4}$ in. The relays are suitable for use in maximum ambient temperatures of 50° C although this may be higher for special applications. For a 4-pole model typical figures are: coil resistance 170 ohms; operating voltage 10 V; pull-in current 36 mA; drop-out current 18 mA; operating time 5 milliseconds; release time 3 milliseconds; and temperature rise after 1 hr, 10° C.

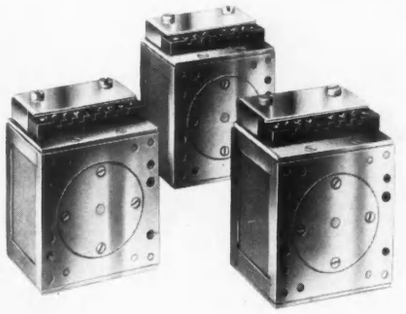


Fig. 2.

Torque Motor

The torque motor, which may be more correctly described as an electromagnetic transducer, consists of a permanent magnet system incorporating an armature which is moved by the passage of current through control windings. The action may be differential or otherwise, depending upon the coil connections. In a single ended system the transducers can be operated against a rate spring. Any degree of magnetic or electrical stiffness may be obtained to suit the particular application.

Feed-back windings or potentiometers can be incorporated. The transducers can be operated completely immersed in oil or provision may be made for fitting oil seals to prevent ingress of synthetic fluids which may have a deleterious effect upon the performance.

There are four standard models in the range, which vary in both size and characteristics, known as the TM12, TM14, TM16 and TM20. The last—the largest, has a linear output of 96 in oz for an input of 120 mA, and an angular movement of 7° on either side of the centre. All models have been tested above 70 *g* and will operate over a wide range of frequencies.

and Patchboard

Patchboards are designed to allow a series of connections to be repeated whenever required, as for instance in computers and machine tool programming. The type developed by Woden consists of two boards, one of which has a matrix of spring-loaded connectors, and the other, the removable one, a matrix of holes in which plug leads can be inserted. The leads have a spring loaded retaining ball in the probe which prevents their being pushed out from the contact end. The connector section of the patchboard slides into channels and is then clamped against the contacts by the end clips. In this way one series of connections can be changed for another in a matter of seconds and any arrangement of connections can be stored till required.

The standard size of board is 7 in by 4 in and has 334 sockets at $\frac{1}{4}$ in pitch. Spigots at one end define the fitting. Contact pressure is between 12 and 14 oz, the contacts being silver plated as standard, but gold plated if required. Maximum continuous current across any contact is 1 A and the voltage drop at that current is 10 mV. Patch cords are available in lengths of 6, 9, 12, 15, and 24 in made up of 44/·0048 wire pvc covered in various colours.

Fig. 3.

CLEANER FOR SMALL PARTS

A BIN tool for use in removing dirt and dust from nuts, bolts, washers, screws, etc., has been produced by the Martindale Electric Company Limited, Westmorland Road, London, NW9.

The tool is extremely simple to use. It can be connected by a suction attachment hose to any type of standard Martindale portable industrial blower. When the blower is switched on the bin tool is held over the bin, tray or tin containing the parts to be cleaned, and these parts are then drawn up into the nose chamber where they are agitated to remove the dust and other dirt which they have collected.

The dirt and dust are drawn through a mesh screen fitted in the top of the bin tool's nose chamber. This ensures that no small washers or nuts are sucked through into the power unit.

A spring-operated lever at the top of the handle can be depressed by the operator's thumb and automatically breaks the suction and the cleaned parts are dropped back into their container.

The tool is light and durable. The nose chamber is constructed of highly-polished aluminium and the handle is finished in mottle grey. It can be used in all conditions and can be satisfactorily operated when working on location if used in conjunction with the Martindale Port-a-Vac harness which enables a blower and dustbag to be carried on the operator's back.

Continuing **Plant and Equipment**

VALVE ACTUATORS

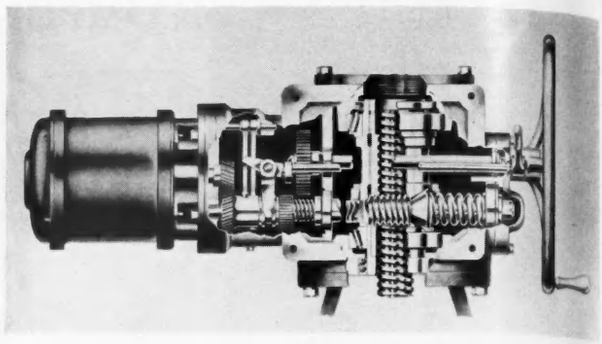
Arrangements have now been completed for the whole range of Limitorque valve actuators to be made in this country by Limitorque Valve Controls Limited, Hanbridge Works, Newbury, Berkshire, a wholly owned subsidiary of Opperman Gears (Holdings) Limited. The licence covers manufacture and sales to all countries outside the Americas and also applies to the latter when the actuator is supplied as part of some complete equipment.

The actuators are normally electrically operated but can also be used with air motors. A typical section is shown in the illustration. The motor, which has a very high intermittent rating, drives through helical reduction gears to a worm wheel which revolves a nut on the valve stem, thereby raising or lowering the latter. A pair of dogs on the shaft allows the motor to gain speed when opening or closing the valve so that a hammer blow is imparted which is enough to unfreeze a sticky valve. The worm is splined on the shaft and held in place by a spring which limits the torque that can be applied so preventing damage if the valve should close on an obstruction. The sliding movement of the worm is in turn used to operate a cutout switch.

The movement is also protected by a travel limit switch which is gear driven from the worm shaft and which has a number of contacts that can be used to give sequence operation of several valves as well as cutting out the motor at the end of valve travel. The contacts are adjustable to suit requirements and to take up wear in the valve seat.

Where a hand wheel is fitted there is also a clutch that is engaged for hand operation and which is automatically disengaged immediately the motor starts to revolve so that the hand wheel is freed and does not constitute a source of danger. The motors are wound to a special specification to give a very high torque, and in addition to the mechanical protection are fitted with thermal overloads. When air is the motive power, a piston type motor is used operating at 100 lb per sq. in; actuators have also been made to operate directly from a natural gas pipeline where the pressure may be up to 500 lb per sq. in; in this case a turbine motor is employed.

Actuators are available for valves of all sizes from 2 in diameter up to the largest made, and for use in all climates. For extra cold conditions heaters can be fitted. The actuators will be on display at the forthcoming Engineering, Marine, Welding and Nuclear Exhibition at Olympia.



Limitorque actuator for remote control of valves.

HOLE VIEWER

The Technoscope is an instrument for examining the interior of small holes down to 4 mm bore. It is made by Hensoldts of Wetzlar and is available in this country from Degenhardt and Company Limited, 6 Cavendish Square, London, W1. The device consists basically of a viewing probe with a separate light source supplied from a battery in the handle or from a transformer. There are four kinds of optical system included: for viewing at right angles to the main bore; obliquely; parallel; and inclined backwards. The latter can be omitted from the set if desired. There are also three models with different lengths of probe up to 140 mm.

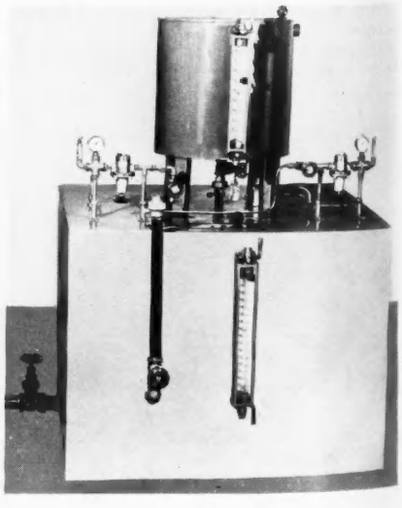
The different probes fit into a contact ring on the main handle which feeds the light. An intermediate ring allows the probe to be turned in relation to the handle. The lamp runs from a three volt supply and the largest set weighs 2 lb 3 oz complete.

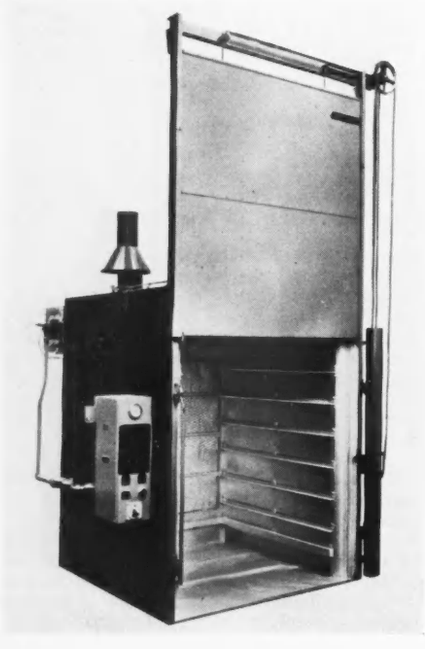
MAKING EMULSIONS

A MIXING unit, the 52 MT, has been developed by Wakefield Dick Industrial Oils Ltd, 67 Grosvenor Street, London, W1. It consists, basically, of a 250 gallon mixing tank surmounted by a 23 gallon header tank; both tanks being fitted with graduated scales to ensure accurate measurements.

In operation, a measured quantity of soluble oil (or other desired fluid) is sprayed over the surface of the water in the mixing tank by air jets. Air also issues from pipes located near the bottom of the mixing tank and the resultant agitation of the fluids ensures complete mixing.

The inlet and outlet pipes on the mixing tank are fitted with control valves and the air supply pipes have control valves and pressure gauges. The header tank can be filled either from portable containers or via a pipe line from remote bulk storage.





GAS FIRED OVENS

A comprehensive range of gas-fired forced-convection trolley-loading industrial ovens, with a choice of direct or indirect heating, and incorporating the latest safety features recommended by the Gas Council and HM Factory Department, has been introduced by Barlow-Whitney Limited, 2 Dorset Square, London, NW1. An example is shown on the left.

They are primarily intended for the larger and heavier type of charge which can be more conveniently handled on mobile platforms or stillages. They can also be supplied with suspension bars, or racks for tray loading or other special arrangements to requirements and are suitable for many process heating applications, including baking, curing, preheating, polymerising and stoving. There are two standard versions—series GD/TLO 300 ovens for temperatures up to 300° C, which are direct-fired units in which the products of combustion pass through the working space, and series GIN/TLO 250 indirect-fired types for temperatures up to 250° C, which are so arranged that the products of combustion are excluded from the working space. Sizes in both styles range from about 100 to 2,000 cu. ft and all models include fully automatic temperature control, flame failure equipment and explosion relief panels.

Companies in the News

The World of GKN

The Guest, Keen and Nettlefold group of companies ranks as one of the largest in the United Kingdom, with some 80 constituent companies and over 60,000 employees. An attempt has just been made to demonstrate to the whole world that they are not merely manufacturers of screws, bolts and nuts, through the publication of a most comprehensive and lavishly illustrated brochure. Fastenings are but one of the numerous activities with which the companies in the group are concerned. Steel is the basis of the great majority of them. Some make iron and steel such as the Guest, Keen and Steel company and John Lysaght's Scunthorpe works, who together employ 9,000 people. The majority of GKN companies, however, are engaged in the production of fabricated components and finished articles, ranging from safety pins to farming equipment and from railway bridges to complete steel buildings.

The history of the constituent companies, a description of their activities, some indication of their size and the location of their factories are given in the brochure. The reason for their growth, and their reputation arises from "a tradition of offering nothing but the best in materials, workmanship and service and of wholehearted co-operation with the many industries which go to make up the group's customers." The brochure has been designed to focus attention on the extensive range of their products, on the extent of their sources and the value of their collective experience. Some of their roots go back as far as 1759, when the Dowlais Iron Works was founded. The screw side of the business was established in 1826 by J. S. Nettlefold, who was primarily responsible for the introduction of automatic screw-making machinery into this country (in 1854). John Lysaght was founded in 1857, Joseph Sankey in 1854, the Patent Nut and Bolt Company in 1864.

So lively and attractively illustrated a publication is an excellent introduction to this group, even to those who have little or no technical knowledge.

Thirty Bridges a Year

A new method of fabricating structural steelwork is being used by the Dominion Bridge Company Limited, of Montreal, Canada, who held their annual meeting earlier this year. A new structural steel preparation aisle, the first of its kind in North America, is in operation at the company's Mount Dennis plant in North Western Toronto. The "all-in-one unit" can cut, drill and clean structural sections in one operation without any conventional in-between handling of materials. It occupies 330 ft by 60 ft of floor space. The company expect the plant to enable them to produce fabricated steelwork "to higher standards of quality and accuracy and at lower costs."

Dominion Bridge's last financial year, to 31 October, was less of a set-back than could have been expected during a recession. Turnover fell by $8 million to $113·2 million, and profits by $1·8 million to $6·3 million. Much of this strength was due to the very heavy volume of work occasioned by the St. Lawrence Seaway project. When the Royal Yacht Britannia sails up the seaway next June for the official opening, she will pass below several impressive new structures by the company. They have completed the fabrication and erection of 3,971 bridges since they were founded 76 years ago, an average of more than 30 bridges a year.

Details of a new regional method of operational control and other organisational changes were announced by the company's president, Mr. H. G. Welsford. A feature of the reorganisation is the creation of four new regions—Eastern, Ontario, Central and Western—each to be controlled by a regional vice-president operating from the head office at Montreal. In addition, a number of special head-office service groups have been set up and three distinct country-wide divisions have been formed—the warehouse, boiler, and mechanical divisions. The changes are designed "to improve its facilities for overall planning, and to provide for greater decentralisation on the branch and operating level."

United View on Steel

Two recent annual reports, one by the United Steel Companies and the other by United States Steel Corporation, sum up very well the outlook for world steel over the next year or so. The report of the United Steel Companies is entitled *Review of Progress, 1958—Report for Employees*. Sir Walter Benton Jones, chairman of the company, writes the following message: "for the first time for 20 years our progress measured by our make of steel has been halted. This is not through any fault of ours. What has happened is that the people who buy steel decided they did not want so much in 1958 as they had been buying in the last few years, and others followed, but not all. This movement should not cause us concern for long and there are grounds for expecting that buyers will think again in 1959, although thoughts about the future can never be a dead certainty." Production of steel for the year ended 30 September was only slightly lower than in 1957 (2·71 million tons compared with 2·85 million) and profits were up a little at £17·55 million. The results for the current year cannot be as good, but signs of recovery are gradually becoming more distinct.

The chairman of US Steel, Mr. Roger M. Blough, is more definitely optimistic in the short term, but a little depressing for the shareholder who looks farther than the next year or two. 1958 was a year of business recession. Production of steel ingots and castings in that year amounted to 23·8 million tons, the lowest tonnage since 1946, and only 59·2 per cent of the company's capacity which, on 1 January this year was rated at 41·9 million tons, an increase of 1·7 million tons in the year. Mr. Blough summarised his company's prospects as follows: "economic conditions are currently improving, depleted inventories are being replenished and durable products made with steel are in greater demand." US Steel are increasing expenditure on research, in which almost 1,000 people are employed at their Monroeville, Penn., laboratory. Vacuum metallurgy is going ahead fast and may soon become adopted as a manufacturing process for premium quality steels. The development of aluminium-coated sheets for use by the motor industry in mufflers was "a typical research activity" in 1958; another was a new high-strength steel composition "USS Airsteel X-200" for use in missiles; a third was vinyl-coated sheets, and there were many more.

In the long term Mr. Blough was depressing because he could not see a recovery in the downward trend of profits in steel making: "corporate profits in this country relative to employment costs have been cut in half during the past ten years, a trend which has greatly undermined corporate incentive." Nonetheless, during the year, the management of the corporation authorised capital investment totalling $513 million, compared with $405 million in 1957.

New Men at Appleby-Frodingham

A number of changes were made at the Appleby-Frodingham works of the United Steel Companies following the regrouping of service departments, including fuel, engineering research, work study, water and oxygen supplies, and the pig casting machine.

Mr. G. C. Oram, at present manager of the central engineering workshops, becomes works manager (production services)—a new position—from 1 April. He will continue to act as technical consultant for engineering workshops to the United Steel Companies, but responsibility for Appleby-Frodingham's central engineering workshop will be transferred to Mr. J. L. Gaskell, chief engineer. Mr. F. J. Watts will become manager of the workshops.

Heaters and Evaporators

A new agreement has been signed between the Incandescent Heat Company and the Swenson Evaporator Company (a division of the Whiting Corporation) of Harvey, Ill., which gives the British company exclusive selling and manufacturing rights in the United Kingdom for all Swenson products. For some years Incandescent manufactured process equipment to Swenson's designs, but they will now have a most extensive range of chemical plant.

To handle this work, Incandescent have formed a chemical plant division, headed by Mr. C. J. V. Denning. In addition to dealing with Swenson evaporators, crystallisers, filters and spray driers the new division will handle sales of direct-fired heaters and combustors, air heaters, high-temperature heat exchangers, furnaces and other thermal equipment for chemical works.

Heaters are also the subject of another recent news item. The Furnace Division of Birwelco Limited, of Aston, Birmingham, have been awarded a substantial contract by the Ministry of Works for an all-radiant air heater for the National Gas Turbine Establishment at Pyestock. It will heat air used in obtaining correct flight conditions when testing aircraft engines. Height of the heater is 73 ft with an outer shell diameter of 22 ft 10 in, and a radiant surface of 6,500 sq. ft. The tubes are 57 ft 6 in long and made from 4-6 chromium, ½ molybdenum, 1½ per cent silicon steel, and stainless steel. The heater is controlled by special equipment operated from a control panel.

English Electric

In his annual statement to shareholders, Sir George Nelson, chairman of the English Electric Company, gave details of trading profits in relation to turnover for the first time, "to illustrate the difficulties of trading at the present time." In 1958 (financial year to 27 December) the turnover of the group was £162 million compared with £148 million in 1957. This increase of £14 million brought an additional trading profit of approximately £800,000, a rate of only 5·7 per cent gross earnings.

Sir George goes on to give details of expenditure per £100 of turnover: materials £48·9, wages and salaries £32·3, depreciation (including power, heat, rent, rates, insurance, and so on) £13·3, interest on loans £1·2 and net trading profit before tax £4·3, out of which over 40 per cent was paid to the Exchequer. Yet less than half the balance was required to pay a dividend of 14 per cent (including 4 per cent interim) to holders of ordinary stock. The fact that the company's latest issue was heavily over-subscribed shows that the stock market has confidence in the company's ability to continue to pay good dividends.

The company's export prospects were reviewed at some length by the chairman. He pointed out that there had been "a considerable upturn in economic activity" in the United States, and could see "no reason to be pessimistic about the future of export trade—either in the immediate future or more particularly in the long run, provided that we study and encourage the provision of appropriate finance." Sir George considers that there is a general climate of expansion, which has been hampered by a shortage of capital. He welcomed the new and improved methods of lending announced at the Montreal Conference which, he thought, "should be of great assistance to the development of power, transport and communications in vital Commonwealth markets." With further prospects of big lending by the World Bank and the International Monetary Fund there was quite a good outlook for exports, and he expected the company to get a good share of an expanding volume of business.

Automobile Engineering

THE GURNEY STEAM CARRIAGE

Working Model of the 1827 Version

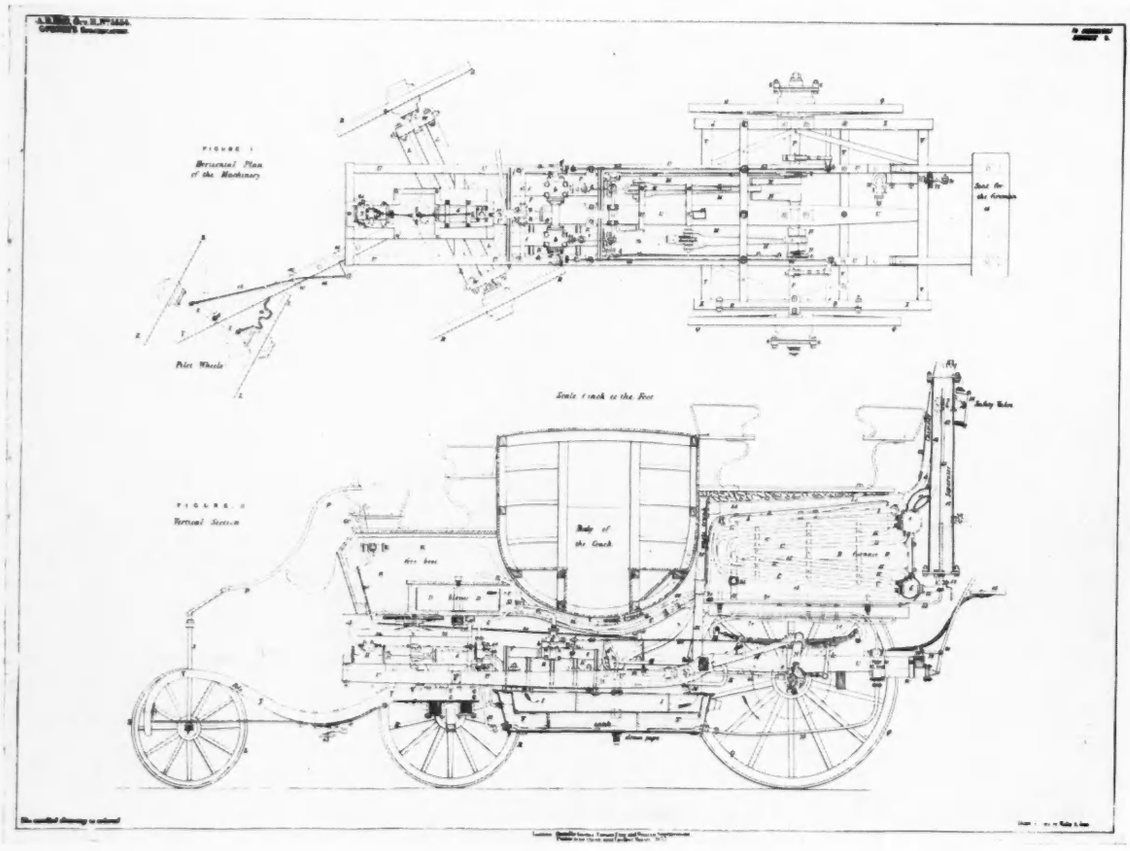
A working model of Gurney's 1827 steam carriage is now on display at the Science Museum.

OF the many might-have-beens of history one of the most fascinating is the steam carriage. But for the fanatical opposition of vested interests there might have been a steam public transport system throughout the country well over a hundred years ago. Indeed, the rise of the railways might never have reached the proportions it did and the coming of the petrol car might have been at least much delayed.

Around about 1830 there were several steam services in regular operation both in London and in the West country. Hancock was probably the most successful; one of his coaches carried over 12,700 passengers to and from the City covering more than 4,200 miles. Another service ran from Stratford to Birmingham with a schedule of six hours, while others ran from London to Bath covering 84 miles of the journey in 10 hours including stops. Top speeds of 20 m.p.h. were regularly being reached in the 1830's.

But opposition to the coaches was intense. It was said that they would destroy the roads, that they would kill the horse—in fact all the arguments that have always been brought forward whenever a new idea takes shape. The opposition took more practical form when landowners and others erected barriers of loose stones up to 18 in wide across the roads, thereby completely stopping all normal horse-drawn traffic but only slowing down the steam coaches which ploughed through the stones, though not entirely without casualties. The last blows, however, were dealt by legislation when speed limits and crippling tolls (up to 20 times those of horse-drawn vehicles) were imposed.

The model was constructed from the original patent drawings.



Sir Goldsworthy Gurney started developing the "horseless" carriage in 1822 and produced several very successful models in the years that followed. Of those he made (most of which ran between Gloucester and Cheltenham, making several journeys a day) the one that is most fully documented is that of 1827. A working scale model of this has now been made by Mr. S. T. Harris from the original patent drawings and is being exhibited at the Science Museum, South Kensington, London.

Two views of the vehicle are given here together with a reproduction of one of the patent drawings. The vehicle contains several elements of design that mark it out as being well advanced technically. It

Atomic Review

Reactivities

REACTORS—concepts, projects, plants in operation—continue to provide the focus of nuclear activities.

Background to the Dragon Project

As reported in Atomic Review last week, the agreement to pursue a joint international research project, to be known as Dragon and to include the construction of a high-temperature gas-cooled reactor, has now been signed. A reactor of this kind was described in detail in ENGINEERING on 12 September last year (vol. 186, p. 336), and the provisions of the agreement were summarised in Atomic Review last 20 February.

The new international project is the third of the OEEC European Nuclear Energy Agency's jointly run undertakings to be put into operation. (The others are Eurochemic a joint concern to undertake the chemical processing of nuclear fuels with a plant at Mol in Belgium; and the boiling heavy-water reactor at Halden, Norway.) The new reactor will be built at the Winfrith Heath Research Establishment of the United Kingdom Atomic Energy Authority, and is designed for investigating the use of high-temperature gas-cooled reactors for nuclear power stations and for other applications. The cost of the project is estimated at some £13·6 million, a basic £10 million being contributed jointly by the United Kingdom (£4·34 million), Euratom (£4·34 million) and the other participating countries (£1·32 million); the remaining £3·6 million will be provided by the United Kingdom, who will retain the reactor and associated equipment.

Dragon Project: Problems to be Investigated

The scope of the research and development work needed for a high-temperature gas-cooled reactor covers a wide range of subjects from neutron physics to specific engineering tests. Many of the more important studies demand the use of irradiation facilities in high-flux research reactors, or of a zero-energy reactor, but a large proportion of the work does not call for such special facilities and the location of this work is therefore not so restricted.

The most important problems needing investigation are given in the following list: (1) the development of fuel-element graphite (or beryllia) sheaths in impermeable forms; (2) the fabrication of high-temperature gas-cooled reactor fuel elements from graphite and beryllia incorporating fissile and fertile materials; (3) the behaviour of the fuel elements and core materials under reactor conditions and changes in mechanical and thermal properties resulting from irradiation; (4) the mechanical properties of the large fuel-element assemblies proposed for the reactor experiment; (5) methods of processing the ceramic fuel inserts after their irradiation; (6) the compatibility of the coolant gas with the fuel elements, at high surface temperatures, and resulting mass transfer problems; the influence of radiation in this connection; (7) the emission of fission products from the fuel inserts, at high temperatures, and their diffusion through the materials of the fuel elements; (8) the development of an efficient fission-product trapping system to remove the volatile and particulate activities from the coolant and to delay active noble gases; (9) the chemical purification of the coolant gases to reduce to acceptable levels those impurities which might cause corrosion and mass transfer; (10) the selection of appropriate structural steels for the primary circuit and the investigation of the behaviour of these materials under the expected temperature and irradiation conditions; (11) the examination of the behaviour of special metals, such as zirconium, which might be used in high-temperature and high neutron flux regions of the reactor, particularly with respect to compatibility; (12) the development of totally enclosed circulating machinery with gas bearings—the behaviour of these gas bearings in helium atmospheres and possible action of coolant-borne carbon and fission product particles; (13) theoretical and experimental studies of fluid flow and heat transfer problems in the core and other regions of the primary coolant circuit; (14) the problems of sealing the primary circuit to prevent the escape of fission products (a high standard of leak tightness comparable to that demanded in high vacuum techniques will be required); (15) methods of processing large volumes of air from the containment vessels or reactor building to remove traces of escaping fission products, which might otherwise be released into the atmosphere (this is primarily a question of removing radioiodine from the effluent air); (16) development of efficient nuclear-radiation shields capable of retaining their properties at temperatures up to 300° or 400° C; (17) theoretical studies of nuclear physics aspects, kinetics and control problems; (18) experimental zero-energy and exponential studies of nuclear physics, kinetics and control problems; (19) development of methods of measurement and instrumentation for high-temperature conditions; and (20) development of certain high-temperature techniques such as the joining of graphite to graphite and the introduction of probes and instruments into very high temperature regions of the reactor.

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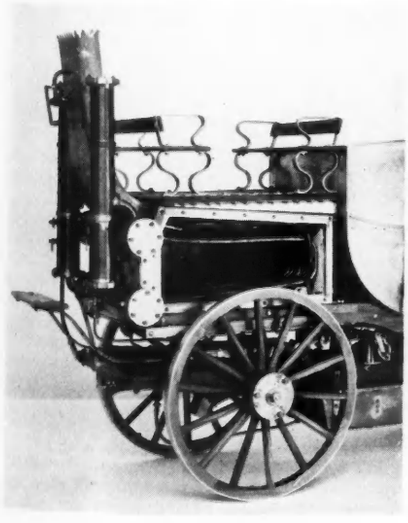
weighed about 3 tons and was capable of speeds of 20 m.p.h.

Perhaps the most noticeable feature is the fore-carriage and pilot wheels, a very early example of servo operation. Owing to the great weight of the vehicle steering by rotating the front axle would have been too heavy to work; therefore the steering control was applied to a pair of leading wheels which in turn led the whole fore-carriage into the curve. A spring return mechanism was used. The water-tube boiler, shown in detail in one of the illustrations, was fired by coke, presumably carried in baskets hung alongside, and had a working pressure of 120 lb per sq. in—higher than was achieved on the railways for a long while afterwards. The engine was a slide-valve two-cylinder double-acting design of 8 in bore and 18 in stroke. The 90° cranks were formed with the back axle. The slide valves were driven from eccentrics and link reversing was used. Auxiliary equipment included a water pump and a blower for the fire, both driven by a separate engine.

Owing to the construction of the road wheels which followed the practice of the time (namely a hub with spokes of wood fitted into the felloes) the drive could not be taken through the hub and spokes as they could not have withstood the torque loading. Consequently a series of studs and arms was used to transfer the torque directly from the axle to the felloes. Normally the drive was to one wheel only, but for hills both were driven.

The coke-fired water-tube boiler had forced draught and a working pressure of 120 lb per sq. in.



Heavy Water and Gas Cooling

The USAEC has signed a contract with East Central Nuclear Group, Inc., and the Florida West Coast Nuclear Group for research and development work on a gas-cooled nuclear power plant of advanced design. The plant will be constructed in the Florida West Coast area, under the Commission's Power Demonstration Reactor Programme. Under the contract, East Central Nuclear Group, Inc., will conduct the research programme to develop a heavy-water moderated, gas-cooled, pressure-tube reactor of advanced design. The cost of this research programme is estimated to be about $18 million. The nuclear plant will generate about 50 MW (electrical) and will be designed as the prototype for a 200 MW (electrical) plant. The prototype plant will use a slightly enriched uranium fuel, but the larger plant would be designed to operate on natural uranium fuel. It is expected that the prototype plant will be completed by 30 June, 1963.

Piqua OMR

Mr. John A. McCone, chairman of the USAEC, has announced in testimony before the Joint Committee on Atomic Energy of the Congress that the Commission will proceed with the construction of an organic moderated and cooled reactor at a new site in Piqua, Ohio. The Commission has made provisions for incorporating additional containment for the reactor. The Commission action was taken following receipt of advice from its Advisory Committee on Reactor Safeguards that a more substantial and dependable containment system than that previously planned for the Piqua 11·4 MW (electrical) reactor would be necessary to ensure adequate protection of the public from a reactor located at the proposed site. The site is close to a populated area.

Hallam Sodium Reactor

The USAEC has selected Peter Kiewit Sons' Company, Omaha, Nebraska, to act as general contractor for construction of the nuclear portion of the Hallam nuclear power facility at Hallam, Nebraska. The Hallam nuclear power facility will be constructed under a cooperative arrangement between the Commission and Consumers Public Power District of Nebraska. The facility which will include a sodium-cooled, graphite-moderated reactor, is designed to produce 75 net MW of electricity. The nuclear power plant will be operated by Consumers as part of its electrical generating system. Atomics International, a division of North American Aviation, Incorporated, of Los Angeles, California, is responsible for nuclear design and procurement of major reactor components. The architect-engineer for the nuclear plant is the Bechtel Corporation of San Francisco, California. The nuclear facility will provide steam for the electrical generating facility. The objective of the nuclear facility is to produce at least 710,000 lb of steam per hour at the turbine throttle. The plant design is largely derived from the Sodium Reactor Experiment (SRE) operating at Santa Susana.

Five Swedish Nuclear Power Projects

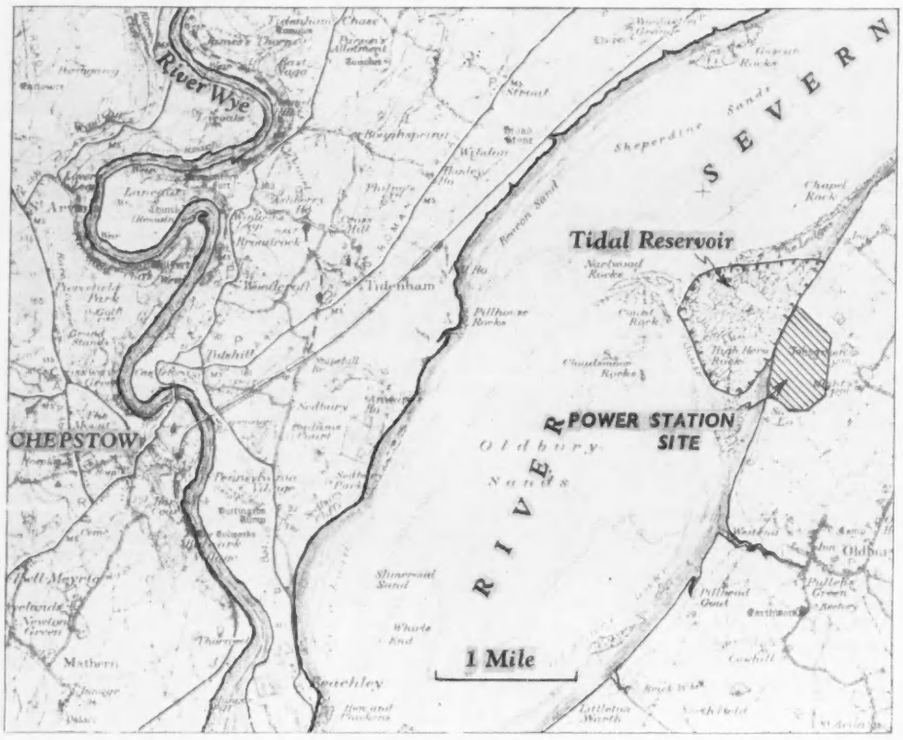
Five nuclear power projects are at present under development at the atomic power division of Asea, the Swedish electrical engineering company, according to a report by the Stockholm daily *Svenska Dagbladet*. Besides the R3-Adam heat and power plant and the R4-Eva power plant, offers are being worked out for three plants for AKK, a combine of eight large Swedish power producers and consumers. A preliminary offer for a 180 MW power reactor, of the organically cooled and moderated type, is said to have already been given to AKK, while the other two are reported to be boiling reactors using enriched uranium, one of them being of 60 MW. For the R3-Adam plant, now under construction at the Stockholm suburb of Farsta by AB Atomenergi and the Swedish State Power Board, Asea is serving as coordinator of detailed design and as main supplier of components in close collaboration with Nohab,

Continuing Atomic Review

the Degerfors steelworks and other Swedish companies. As regards the State Power Board's R4-Eva project, Asea is engaged in type studies together with Atomenergi, Bofors and Nohab. In collaboration with the latter company Asea has a preliminary commission to prepare a design for a water-cooled reactor of 200 MW electrical capacity. The Swedish atomic programme has so far been based on the use of natural uranium as fuel and heavy water as coolant and moderator. The R4-Eve project is expected to be completed by 1965.

Second Severn Site

The Central Electricity Generating Board are to make application to the Minister of Power and to the Local Planning Authority for consent to develop a site of about 175 acres at Oldbury-on-Severn for a nuclear power station. The site lies on the south eastern bank of the Severn Estuary 14 miles north of Bristol and 4½ miles



A site being investigated by the Central Electricity Generating Board for a nuclear power station would make use of an artificial tidal reservoir.

downstream of Berkeley where one of the Board's first two nuclear power stations is under construction. Advantage will be taken of a rock shelf off-shore to create an artificial tital reservoir, shown in the accompanying illustration, from which the large quantities of water required for cooling the condensers of the steam turbines can be drawn during low tide periods. This unusual arrangement will reduce the costs that would normally be incurred in obtaining cooling water from an estuary with as wide a tidal range as the Severn. Foundation conditions on shore are good for supporting heavy reactors. Present indications are that a station on this site might have a total output of about 1,000 MW and be connected to the 275 kV Supergrid.

Further Sites for CEGB Stations

Investigation of three other areas on the Severn Estuary is continuing to determine whether they are suitable for future nuclear power station development. These are at Tidenham, Aust and Portskewett. The investigation of sites at Earnley in West Sussex and Hamstead in the Isle of Wight was reported in Atomic Review last 27 February. Three nuclear power stations are now under construction by the Central Electricity Generating Board at Berkeley, Gloucestershire (275 MW), Bradwell, Essex (300 MW) and Hinkley Point, Somerset (500 MW). Preliminary works have been started for the construction of a fourth station at Trawsfynydd, Merionethshire (500 MW) and applications have been made for consent to establish stations at Dungeness in Kent and Sizewell in Suffolk. The South of Scotland Electricity Board has a station under construction at Hunterston (320 MW).

Shield Construction at Hunterston

The steady growth of Scotland's first nuclear power station at Hunterston, on the Ayrshire coast, continues to be maintained; and about a quarter of the total period allowed for constructing and commissioning the station is now through. The first reactor building has already reached an advanced stage and the supporting skirt for the reactor pressure vessel has been erected inside the concrete shield. Meanwhile, rapid progress is being made with civil engineering work on the second reactor, the turbine hall, and the extensive circulating-water system, and a start has been made on the construction of several ancillary buildings. The illustration opposite shows the standpipe sleeves being placed in position prior to the casting of the bottom biological shield in the first reactor building. The 320 MW power station is being built for the South of Scotland Electricity Board by the GEC—Simon-Carves Atomic Energy Group.

The reinforced concrete shield walls of the first reactor building have now reached a height of approximately 120 ft above the foundation raft. For constructional purposes, both the inner and outer walls were divided radially into eight sections; the concrete was placed in 5 ft lifts, diametrically opposite sections being cast in turn. A single lift of this size on one section of the wall contains between 80 and 120 cu. yd of concrete, a quantity which can easily be placed in one shift. Gaps of 6 ft were left between adjacent sections to minimise shrinkage effects, and these gaps were concreted at a later stage. The concrete has been cured by spraying the surface with "Ritecure," a material which forms a sealing membrane, as soon as the shutters have been stripped. The membrane begins to evaporate after about four weeks, leaving a generally good standard of finish.

One of the most difficult operations in the civil engineering of this reactor has been the casting of the bottom biological shield. This shield, above which the reactor pressure vessel will be built, is circular and rests upon a rebate formed in a ring beam carried by eight massive supporting columns. It is 6 ft 6 in thick and its lower surface forms the roof of the chamber in which the charge-discharge machine will operate. The 101 standpipes through which the charge-discharge mechanism gains access to the interior of the pressure vessel must pass through the shield, and steel sleeves were cast in for this purpose.

The bottom shield contains 397 cu. yd of special heavy concrete, made with Grandesburg iron ore instead of ordinary aggregate, and is heavily reinforced. Before concreting began, the standpipe sleeves were accurately positioned on the timber shutter by means of a cruciform jig at the bottom and by metal lugs welded to the surrounding reinforcement at the top. Placing the concrete into the complex structure formed by the sleeves and the reinforcement presented many problems, particularly as it must be carried out in a time short enough to ensure homogeneity of the concrete and to maintain a minimum density of 212 lb per cu. ft. Two mock-ups of a section of the shield were made and concreted to determine the best way of meeting these problems. Using the method proved by these tests, the shield was successfully cast in a continuous process taking 39 hours.

The top biological shield above the pressure vessel will be partially formed of, and supported by, massive concrete beams. These beams, the largest of which weighs 308 tons, have already been precast on the area between the two reactors and will later be lifted into position by the 300 ton Goliath crane. Much time and labour have also been saved by precasting slabs to form floors at various levels inside the "blimps" between the inner and outer shield walls.

Operation Sunrise

According to *Nucleonics*, the General Electric Company of America has undertaken a major development programme to bring three complementary boiling-water reactor concepts to a competitive position by 1970. The three systems are: natural-circulation boilers, forced-circulation boilers and nuclear-superheater boilers. The programme is called Operation Sunrise.

Heavy Water—Thoria—Urania and EBWR-2

An experimental programme to establish the nuclear properties of thoria-urania-heavy water systems has been initiated in the US since there are advantages in a boiling power reactor of this composition. A ceramic composed of thorium oxide with a relatively small amount of enriched uranium oxide is particularly attractive as a fuel element for use in water reactors because of its corrosion and radiation stability, simplicity and economy in fabrication, and the utilisation of thorium reserves by conversion. The technology of high-temperature, water-cooled reactors is well developed, and extensive experience has been acquired recently with a thoria-urania-light water boiling reactor, BORAX-4. A direct-cycle, boiling, heavy-water reactor has certain advantages over a pressurised system or a boiling, light water design. These include the well-known simplicity of producing steam in the primary coolant loop; clustered fuel arrangement which lends itself readily to a forced circulation arrangement and high power densities; the safety associated with a long neutron lifetime; and excellent neutron economy. . . .

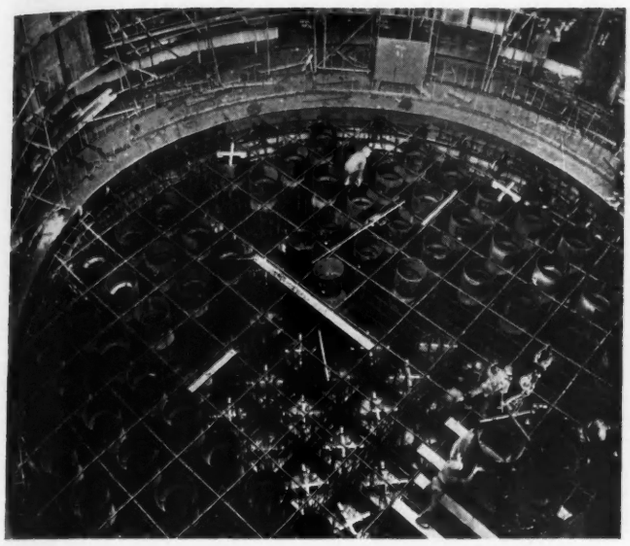
One of the motives for the ZPR-7 experimental programme was to accumulate data of use in designing the EBWR-2. This is intended to be a small prototype reactor the function of which is to demonstrate the feasibility of the direct-cycle boiling heavy-water concept. (W. C. Redman and J. A. Thie, *Properties of Exponential and Critical Systems of Thoria-Urania and Heavy Water, and Their Application to Reactor Design*, Geneva Conference P 600, USA.)

Fluidised Breeder Reactor

The fluidised solids technique, used so extensively in the petroleum and chemical industries, has been investigated for possible adaption to

nuclear power-breeder reactors. Several designs have been studied and detailed engineering and nuclear calculations carried out for the design considered to have the greatest promise for a large electric power station. Basically, the design calls for the circulation of solid particles consisting of fuel-moderator mixture, from the core to a separate heat exchanger vessel from which the solids flow freely to and through the core by gravity. Argon, at essentially atmospheric pressure, is recommended as the gas to be used in circulating the solids and fluidising them in the heat exchanger.

The blanket, consisting of solid particles of moderator and fertile material, is separated from the core region by means of a graphite shell and is fluidised by a separate gas stream. Among the advantages of this system are the high breeding gain obtainable, utilisation of basic engineering principles at present in use in industry, and the ability to produce steam at pressures and temperatures comparable to those now available to the power industry. Nuclear calculations were made using 2-group 2-region method. A typical system, operating at 250 MW (heat output) and producing over 80 MW electrical power, requiring a 10·5 ft (diameter) core, a 3 ft thick blanket, and 48 kg of uranium 233 in the core proper, has been considered. Additional hold-up of fuel in the heat exchanger and blanket brought the total fuel inventory to something less than 200 kg. Breeding gains of over 0·2 were calculated even after consideration was given to the poisons, leakage, and core shell absorption. (R. R. Halik, L. H. Beckberger, J. M. Haibeck, J. E. Mealia, W. A. Northrop, D. R. Rees and W. A. Robba: Oak Ridge School of Reactor Technology, Tennessee, USA, Nuclear Science Abstracts).



The standpipe sleeves being placed in position before casting the bottom biological shield in the first reactor building of the Hunterston nuclear power station.

Reactor with Reciprocating Engine

The possibility of coupling a high-temperature reactor directly to a gas turbine has long been looked on as an attractive prospect; but a new proposal involves the use of a reciprocating engine. A preliminary design study of what is called a " nuclear gas engine " has been carried out under contract for the Oak Ridge National Laboratory, USA. It consists of a gas-cooled reactor coupled to a reciprocating engine, and the report compares it with other reciprocating engines and air compressors.

Fast Reactor Melt-Out Containment

The danger of criticality due to the collection of fissile material in the base of the reactor vessel following melt-out of a fast reactor core has been averted by providing the vessel with a concave end, so that the highly enriched material runs into a circular channel rather than a central pool. However, the nature of plutonium (either used as fuel enrichment or produced by irradiation of uranium 238) is such that chemical action with the vessel is likely to make containment short lived. The presence of liquid sodium further complicates the situation and solidification may be seriously delayed. There are thus formidable materials problems to be solved before a commercial fast reactor can be built.

Notes and News

Revised Structure of the UKAEA

Changes in the organisation of the United Kingdom Atomic Energy Authority to be effective from 1 July, 1959, were reported in Atomic Review last week. Hitherto the Authority has comprised three groups: the Research Group, the Weapons Group and the Industrial Group. The Industrial Group, which has become too large for convenient management, will now be divided into two: the Development and Engineering Group, and the Production Group. At the same time the full-time technical members of the Authority will again assume executive responsibility for particular groups, in addition to their functional responsibilities and general duties as members of the board. Sir William Cook, with the title of member for development and engineering, will be executive head of the Development and Engineering Group and will, in addition, retain corresponding functional responsibilities through the Authority. Sir Leonard Owen will have the title of member for production (designate) and will be the executive head of the Production Group. Sir William Penney, whose appointment to succeed Sir John Cockcroft as the member for scientific research, has already been announced, will in addition become the executive head of the Research Group, while retaining his functional responsibilities for scientific research throughout the Authority. The appointment of a successor to Sir William Penney as member for weapons research and development is to be announced later. The responsibilities and composition of the new groups are described below.

The Development and Engineering Group will be responsible for development, design and construction of reactors and associated plants (with the exception of certain development work which will continue to be undertaken by the Research Group); engineering consultant work for the electricity boards, overseas organisations and the consortia; and general engineering design and construction of all major building projects.

The D. and E. Group will include headquarters staff at Risley, Lancashire; the Dounreay Experimental Reactor Establishment, Caithness; the Culcheth Laboratories, Lancashire; and research and development organisations at Capenhurst (Cheshire), Windscale (Cumberland), and Springfields (Lancashire).

The Production Group will be responsible for the operation of the Authority factories (including the Calder Hall and Chapelcross reactors); research and development in aid of factory processes; and commercial activities of the existing Industrial Power Branch.

The Production Group will include headquarters staff at Risley (Lancashire) and plants at: Capenhurst (Cheshire); Springfields (Lancashire); Windscale and Calder (Cumberland); and Chapelcross (Dumfriesshire).

Japanese Letters of Intent

Dr. T. Ipponmatsu, vice-president of the Japan Atomic Power Generation Company, is said to have reported favourably in connection with the 150 MW nuclear power station to be built by GEC—Simon-Carves for his company, and letters of intent are expected to be despatched immediately. (See Atomic Review 27 Feb. and 6 March.)

Fuel for Japanese Power Reactor

Fuel for the projected Japanese nuclear power station is expected to be bought outright by the Japan Atomic Power Generation Company under a loan provided by British finance houses. Repayment would be made through a charge on the running costs. Normally the initial fuel charge forms part of the running costs, and the credit allowed by the UKAEA for the spent fuel is regarded as an operational profit. The cost of the fuel will be, it is understood, about £21,000 a ton.

New Japanese Group

It is reported that a new Japanese atomic energy group is being formed. The members are to be Meidensha, C. Itoh and Company, Yamatake-Honeywell Instruments, Nippei Industries and Japan Carbon.

Export Prospects Analysed

Prospects for Nuclear Power is the title of a booklet published by Political and Economic Planning, 16 Queen Anne's Gate, London, SW1. After summarising the major nuclear programmes, the booklet treats in detail market prospects for the sale of power reactors. " Potential sales," comments the booklet, " are lessened by the fact that a country which is industrialised enough to be able to use atomic power is at the same time able to make for itself a good deal of the equipment necessary . . . and potential customers are to be found mainly in Europe, plus Japan and India and parts of Latin America. . . . The prospects for British firms to export reactors are probably not so bright as they were once thought." The broadsheet stresses the importance of supplying fuel as an encouragment to sales and the part played by international politics in commercial affairs.

Euratom Second General Report

The second general report of the Euratom Commission, published last week, underlines the importance which the commission attaches to the rapid establishment of a community research centre. It has decided against a completely new centre, as this would take too much time; it is currently considering whether some of those already in existence might be put, wholly or in part, at its disposal. In the meantime the commission is actively pursuing a programme of research on heavy-water reactors (which will include the construction by the commission of a prototype reactor), material-testing reactors, and plutonium. Other important research work is to be undertaken by outside bodies for the commission. The first contracts for this will deal with radiobiology, plutonium and controlled nuclear fusion. Negotiations for a common programme on the latter problem are in force with the French Atomic Energy Commission, and also the Max Planck Institute at Munich.

Mitchell Enterprises

It is reported that the Mitchell Engineering Group have discussed the possible supply of a small nuclear power plant having an initial capacity of 17·5 MW and a reserve capacity of 4·5 MW with the Government of British Guiana. The cost would be roughly £3 million. It is also understood that Mitchell are studying other South American markets. In particular their representatives have visited Rio de Janeiro to discuss the possibility of installing a 20 to 30 MW power reactor in the north of the state. Mitchell are also said to be engaged on a nuclear-powered cargo-submarine project.

In Parliament

LIQUID METHANE SUPPLIES

Problems involved in the importation into Britain of supplies of liquefied gas were again discussed in the House of Commons last week, when Mr. Harold Neal (Labour) asked if the Paymaster-General had as yet given any general direction to indicate which area gas boards were to pioneer the use of liquid methane.

He asked whether it was to be assumed that the area boards to undertake such developments would be those situated nearest to port facilities and whether, if so, there was any arrangement in contemplation whereby the inland gas boards would be able to share in the reductions which would be obtainable in the price of gas.

Sir Ian Horobin, the Parliamentary Secretary to the Ministry of Power, replied that the work at present being undertaken in this connection was being carried out by the North Thames Gas Board. Only one vessel had so far conveyed the gas across the Atlantic and several more trips of this " very interesting ship " would be required before the Ministry could get down to calculations of the economic aspects. He was not making a promise, but perhaps in a few months' time, the Ministry would be in a position to say more on the matter. The figures were under examination, but it was impossible to be very explicit.

CHECKING AERO ENGINE CONTRACTS

A statement was sought by Mr. Frank Beswick (Labour/Co-operative) from the Minister of Supply regarding the operation of penalty clauses in development contracts for aero-engines. He referred to the losses of some millions of pounds on the Bristol Proteus 1 aero-engine and on the Bristol Brabazon aircraft and asked to what extent the technical staffs of the Ministry had been strengthened to ensure the more effective checking of calculations submitted by manufacturers engaged on such contracts.

It was pointed out by Mr. W. J. Taylor, the Parliamentary Secretary to the Ministry of Supply, that development contracts for aero-engines did not include penalty clauses. Their absence was because the work to be accomplished, by its very nature, rendered initial estimates and calculations liable to a margin of error. They were inevitable when a new development was embarked upon which would take some years to complete and for which success, in its original conception, could not be guaranteed.

There had been some strengthening of the technical staffs, but improvements in checking estimates and calculations depended more upon improving the techniques of estimating and the Ministry's efforts to that end had also been increased. It was the Ministry's policy to include in development contracts provisions designed to keep a close watch on rises in costs and the causes of such increases. The Ministry also reviewed regularly the value of projects in hand and sought to ensure that it was not liable for any increases over the estimates that had been submitted unless such increases had been specifically approved.

He told Mr. Roy Mason (Labour), in answer to a similar question, that the Ministry tried to analyse precisely what a particular project entailed and to bring informed critical judgments to bear on estimates of cost at each stage.

FOG DISPERSAL EXPERIMENTS

The Ministry of Supply was asked by Mr. Austen Albu (Labour) to make a statement about any further progress which was taking place in the system of fog dispersal, originally initiated on the Minister's behalf at the Battersea College of Technology. Dealing with a very similar method of fog dispersal, the Secretary of State for Air had recently told the House that it was a very promising idea. Why was it that there appeared to be no co-ordination between the two departments on this important subject?

On this matter, Mr. W. J. Taylor said that no further steps were being taken regarding the experiments at Battersea College. The method of fog dispersal investigated at the college had not proved sufficiently promising to justify further development. It was not a question of any lack of co-ordination between the two ministries, but merely a question of differing opinions between the scientists involved.

Work at Battersea had been based on the idea that fog might be dispersed by accelerating the rate of coalescence and precipitation of the minute drops by spraying surfaces with an active agent and using an aeroplane for that purpose.

INVESTIGATING ROAD PROBLEMS

An inquiry was made by Mr. Ernest Davies (Labour) as to whether a review had yet been undertaken to determine which government department should control the Road Research Laboratory. He pointed out to the Parliamentary Secretary to the Ministry of Works that such a review had been recommended by the Select Committee on Estimates in their fifth report of the parliamentary session for 1957-58.

Mr. Harmar Nicholls replied that an inter-department review of the control of the stations to which the committee had referred had been begun and that the question was still under consideration. He appreciated the importance of the matter but he could not give any indication of how long the investigation would take.

Another point raised by Mr. Davies, and also based upon a recommendation in the same report of the Select Committee, was that tenders received from contractors for road work to be done to new specifications should be submitted to the Road Research Laboratory and that the laboratory should be informed of the results obtained. In this connection, Mr. Nicholls said that arrangements had been made to increase the already substantial collaboration between the Ministry of Transport and Civil Aviation and the laboratory.

HARDSHIP TO SMALL BUSINESSES

Cases of hardship caused to small business people in or on the verge of clearance areas, who lose both their business and its goodwill, as a result of clearance schemes, were brought to the attention of the Minister of Housing and Local Government by Mr. S. S. Awbery (Labour). He considered that the Minister should introduce a scheme for compensating such people against losses of this kind, which, in most cases, deprived them of their livelihood.

Mr. Henry Brooke replied that local authorities were empowered under the Housing Act, 1957, to make discretionary payments to business occupiers in clearance areas, if their interest was so limited that there was no basis for statutory compensation. They could also make payments to meet the personal hardship to any shopkeeper in the locality of a clearance area whose business suffered because the population had decreased. He doubted whether it would be practicable to introduce any statutory scheme for compensation in this type of case. But he intended to remind local authorities once more of the desirability of making appropriate use of their discretionary powers.

ENGINE EXHAUST FUMES

Research on combustion in diesel and petrol engines, with a view to reducing the emission of exhaust fumes, is being carried out by the Motor Industry Research Association and the British Internal Combustion Engine Research Association. Mr. Harmar Nicholls told Mr. Ernest Davies that each of these two bodies is supported by the Department of Scientific and Industrial Research.

Mr. Nicholls said that the results of their investigations, and other work on the subject, had shown that the greater part of the smoke from such engines could be prevented by their proper running, adjustment and maintenance. The Warren Spring Laboratory of the DSIR had tested a catalytic device which reduced the pollution from petrol engine fumes effectively.

From everyone's personal experience, it was a fact that, in far too many cases, the proper maintenance of these engines was not being carried out, resulting in the emission of unpleasant fumes. The position was well known and anything that could be done by the DSIR, to ensure that the authorities which could insist upon adequate maintenance did so, was being done. The discussions on this problem which took place in the House from time to time underlined not only the importance which the Department attached to the reduction of exhaust fumes, but the importance which the House attached to ensuring that action was taken.

Wages on the Kariba Dam

Replying to Mr. George Pargiter (Labour), who had asked about the causes of the recent strike among employees working on the Kariba Dam, Mr. Alan Lennox-Boyd, the Secretary of State for the Colonies, said that the average weekly wage paid to African workers was 41*s* 3*d*, exclusive of food and quarters. On 25 February, the workers on the north bank ceased work in support of the demands of underground workers on the south bank. The majority returned to work the next day, although 150 out of 730 elected to be repatriated by the employers, as did 38 Northern Rhodesian Africans employed on the south bank. In the light of local conditions and local comparisons, he did not think that the wages paid were unfair.

Hong Kong Airport

The new runway at Hong Kong Airport was opened on 12 September, 1958. Mr. Julian Amery, the Under-Secretary of State for the Colonies, said that a 600 ft extension, which would bring the total length of the runway to 8,350 ft, together with an ancillary taxiway and aircraft park ramps, was to be completed in June. He told Mr. Edward du Cann (Conservative) that new navigational aids, including PAR (precision approach radar), VOR (very-high-frequency omni-directional radio range), ILS (instrument landing system), approach radar, long-range radar and lighting system would be installed between May, 1959, and April, 1960. Completion of the new terminal building was forecasted for early 1961.

Low Temperature Carbonisation

Information was sought by Mr. Patrick Maitland (Conservative) regarding the extent to which the Government was prepared to encourage the development of improved low-temperature carbonisation processes for the production of oil and smokeless fuels from stocks of surplus coal. He was informed by Sir Ian Horobin, Parliamentary Secretary to the Ministry of Power, that the preference allowed on indigeneous oils offered a substantial measure of assistance to the production of oil from coal. The Minister, Lord Mills, had already announced that his Scientific Advisory Council had been asked to investigate the possibilities of increasing the research and development of all practical processes for the production of oil, gas and chemicals from coal.

Wood for the Railways

A plea was made by Sir A. Bossom, Bt. (Conservative), that the Minister of Transport and Civil Aviation should give a general direction to the British Transport Commission to use all-metal railway carriages and freight cars. He pointed out that the cost of importing wood was high and constituted a strain upon the nation's resources. Mr. Harold Watkinson, however, declined to take such action, saying that the matter was a management one for the Commission. Only a small proportion of timber imports was used for railway rolling stock. For many years, all new passenger coaches had been built of steel, with wood used only for interior fittings and panelling. No wooden freight wagons were now being built, except where necessary for special purposes.

The Human Element

Keepers of the Countryside

Our island is small, its population large, its industry tremendous—by comparison with any other concentration anywhere in the world—and growing fast. Preserving what countryside we have and the animal life upon it is a major task. For ten years now it has been the job of the Nature Conservancy. To mark the occasion of their tenth birthday the Conservancy have published an account of themselves and their activities in an attractively illustrated 36 page booklet (*The Nature Conservancy: The First Ten Years*, price 1*s* 6d).

People who have heard of the Conservancy only in some particular connection—or not at all—will be surprised at the width of its scientific studies which, as the booklet shows, account for just about half the current annual expenditure of £350,000. Only about 4*s* in the pound is devoted to nature reserves. These have been acquired at the low average cost of 36*s* 2d an acre for purchased freehold land and 7*d* an acre yearly for those declared under nature reserve agreements. Every hour, since the charter ten years ago, has seen on average another 1½ acres of national nature reserves acquired. Coloured maps show how 72 of these are scattered between the English Channel and the northern and western islands off Scotland. The booklet explains how the Conservancy's researches help in managing the reserves, while the reserves in turn serve as outdoor laboratories for the researches. More widely, these researches will, it is claimed, help us to learn "how to use nature as a valuable partner rather than a shabby doormat, and to avoid the evils and disasters arising from what has been called 'the rape of the earth.'" The right scientific investigations rightly applied can remedy many past and present mistakes in land use and land management arising from ignorance.

The problems being tackled by the Conservancy range from the merits and dangers of introducing reindeers into Scotland to the use of vegetation for conserving water supplies on high catchment areas and the restoration of Sutton Park near Birmingham after 40,000 Boy Scouts from all over the world had held a jamboree on it. Ten years ago they employed just over 20 staff, most of them non-scientific. In 1958-59 they had on their payroll over 70 scientists and 115 non-scientific staff. With a powerful board and under the energetic leadership of E. M. (Max) Nicholson, the Conservancy will meet the many challenges that await them during the second decade of their life. Here are the facts, as summarised by themselves. "Water and air have become polluted. Soil has been washed or blown away, or its fertility has been lost. Floods and water shortages have grown more serious in many places. Opportunities have been created for the spread of weeds and pests. Shelter has been destroyed through cutting down woods and uprooting hedgerows. Beautiful and interesting landscapes have been ruined by unwise treatment." But much has been achieved over the past ten years and the outlook is hopeful. The booklet tells the background story of the struggle to defend nature and the countryside.

A Little Late this Year

At this time of the year the pattern of the annual round of wage claims has usually taken shape. This year things are moving a little more slowly on the wages front, partly because the recession has counselled caution and partly because some trade union reputations were a little tarnished in the course of last year's negotiations.

There is plenty of room for trouble. The printing unions are highly dissatisfied with the employers' attitude on their demands and the militant element in the National Union of Railwaymen has made a bold bid to win back lost ground by forcing a wage claim before the British Transport Commission and deciding to withdraw the NUR from the joint consultation machinery. The miners are seeking a shorter working week along with the wool textile workers. There is a deadlock in the building industry about a claim for 4*d* an hour.

This month will also see a claim under discussion for road-haulage workers and local government officers. Farm workers are claiming a shorter working week and a quarter of a million co-operative employees are claiming a 5 per cent rise. It is a late spring but everything is coming on with a rush.

People Versus Capital

In these days when it is so readily assumed that higher productivity and higher output are mainly obtained from a greater rate of capital investment, it is as well to remember that this is probably not so. The statistical evidence available is somewhat sparse, but so far as it goes, it shows that the key factor is the human element. This element is a combination of organisation, technical knowledge and sheer hard work—in terms of both brain and brawn.

The Swedish bank review *Index* has recently drawn attention to this fact. It has brought together in a note a series of figures recently put together in Norway to try to prove this point about the human element. When statistics from three countries were brought together they showed remarkably similar results. The three countries were Norway, Finland and the United States. In each case it was found that better organisation accounted for between a 1·2 and a 1·8 per cent increase in output for every 1·0 per cent of increase brought about by greater applications of fixed capital and labour combined. As between capital and labour, a greater rise of output was obtained from more labour than from more capital.

Results like this are, of course, both approximate and relative. They highlight what is generally admitted, namely, the most industrialised communities lose more from the inefficient use of resources than from a lack of those resources. On this sort of basis the worst performance of all might well be turned in by the United States where intensive applications of capital are particularly easy to achieve.

Hours and an Ill Wind

In the United States the AFL-CIO executive council has called upon Congress to amend the wage-hour act to provide a 35 hour week and a 7-hour day. This they say is the simplest and most practical way to get a universal reduction in the working week. It certainly is.

This latest manoeuvre has been touched off by the rise in productivity of labour as the United States comes out of the last recession. As is generally known, the rise in industrial production has not been accompanied by a corresponding increase in employment. The unions therefore want to safeguard the position of labour by spreading the work over more people to offset unemployment. This is the purpose of the 35 hour week. The 35-hour limit would of course stay on long after the immediate problem of unemployment had gone.

It will never be possible to find out how far the ability of factories to raise productivity, as output expands after a recession to pre-recession levels, springs from higher investment, less inefficient management (because the managers have had a bit of a fright) or fewer restrictive practices (because labour has had an even bigger fright). The same tendency on the upswing of a trade cycle has been noticed this time in this country and the same plea for shorter hours (notably from the AEU) has occurred. Management is not likely to give in (any more than is the US Congress), for, as the trade cycle goes on, everyone will tend to become occupied with demands for wage increases rather than shorter hours.

Entering the Chemicals

Regulations for the Admission of Student, Graduate and Corporate members, and for the Examination of the Institution, published by the Institution of Chemical Engineers, has been substantially revised this year. The booklet now contains some guidance on "training and experience" requirements for associate membership and a new syllabus for paper D (engineering drawing) of the Institution examination which is to come into force starting with the 1960 examination.

The revision of this syllabus is aimed at giving teachers and students more advice on the content of this part of the examination. On the reverse of the leaflet, on which the revised syllabus for paper D is printed, are the new rates for membership subscriptions: members resident in the United Kingdom now pay 9 guineas a year, students less than 21 years old pay one guinea. The entrance and transfer fees remain unchanged.

Council Housekeeping

A lot of water has passed under the bridge since the opponents of housing estates (municipal or otherwise) opposed them because the tenants would keep coal in the bath. Today in England and Wales local authorities own three and a quarter million houses and flats and are landlords of about one quarter of the population. This population is no longer entirely a "working class" cross-section and it is probably a grave mistake to manage the houses it occupies as if it were.

These and other facts are brought out in a report issued by the Ministry of Housing and Local Government called *Councils and Their Houses* (HM Stationery Office: price 2*s* 6*d*). The committee, under the chairmanship of the Dowager Marchioness of Reading (who is also chairman of the Women's Voluntary Service), was appointed in 1957 to review the management of housing estates and the functions of housing managers.

Three conclusions in particular are endorsed by the Minister. These are that housing management should be the responsibility of a main committee, that all aspects of housing management should be brought together in one department and that when a single department is not considered practicable the natural arrangement is for the manager to be responsible for all matters bringing landlord and tenant together, and the engineer or surveyor for repairs.

Teaching By Work Study

At Josiah Wedgwood and Sons Limited, the raising of productivity by work study created a problem of producing enough skilled workers to keep up with a trebled rate of output. How this was solved is told in the latest issue of *Target*, the monthly bulletin of productivity.

A way to speed up the rate of training was devised through applying work study to the performance of skilled workers. It was found for example that experienced workers were quicker than inexperienced ones, not so much because they do the fast movements faster, but because they do the slow movements more quickly. The difference lies less in the speed of movement than in the manner by which the senses collect information from the job for controlling those movements. The object became to establish standard training procedures for each department and to show that they would work in practice.

Special Article

SEARCHING FOR OIL IN AWKWARD PLACES

The need for new oil reserves persists even though the resources from established oilfields are sufficient to satisfy the present demands and the current world situation is one of over-supply. The oil industry is looking to the future. By 1975 it is estimated that the Free World will double its present consumption of oil—from 900 million tons to 1,800 million tons annually. Crude oil is being sought in every likely area.

In the mangrove swamps, near Calabar, in Eastern Nigeria.

OIL, it is said, is where you find it. But it is becoming increasingly difficult to find since, for the most part, it is located in remote and undeveloped regions—in jungles, in deserts and under the sea.

Teams of men and costly equipment have to be established in the wilderness to find and gain the oil from the ground and provide the means of transporting it away. Perhaps a town must be built to house oil workers and their families; or a pipeline, such as the Tapline system, from Abqaiq to Sidon, constructed at a cost of some $230 million, which works out at £80,000 per mile. Oil, they say, is where you find it and the search for oil is unceasing.

During the ten years between 1947 and 1956 nearly £1,000 million has been spent by the oil industry for the acquisition of acreage and in wild cat and development drilling. In the USA, of the 11,383 explorary wells drilled in 1957, 843 were oil, 120 distillates, 239 gas and 10,181 (approximately 90 per cent) were dry.

In Swamplands

The first locally produced crude oil was shipped from Nigeria to Europe only as recently as last year. This represented the first concrete reward for a monumental job of exploration that, begun in 1937, has so far cost over £40 million. The search area extended over some 38,000 square miles of Nigeria, including deep bush and the mud and swamps of the Niger Delta. Exploration parties, engaged in geophysical and test drilling operations, depended to a large extent on helicopters for essential supplies and high powered radio sets for communication.

In early 1956 the Shell-BP Petroleum Development Company of Nigeria encountered a promising show of oil at Oloibiri, 45 miles west of Port Harcourt, a location deep in the Niger Delta region of tangled mangrove swamps, 9,000 square miles in extent. This meant, when test production began, that a pipeline had to be constructed through the swamps to Port Harcourt, 70 miles away, from where the oil could be shipped.

Today Oloibiri is Nigeria's first oilfield, producing 3,000 barrels a day. Oil is also being pumped to Port Harcourt from Afam, 20 miles east of the port.

Both these fields, however, appear to be small and complicated. More production experience must be obtained before the economic aspects of these fields can be evaluated satisfactorily.

Between Jungle and Water

When oil exploration parties are faced with difficult country in these days they look to the air for help. In the middle Magdalena valley in Colombia seismic parties of Shell Condor SA are working in a region of dense tropical forest, swamps, lakes and rivers. In such terrain helicopters are worth many times their weight in mules, trucks and boats, for they afford access to areas which cannot be reached by other means. They fly between 165 and 370 hours a month, carrying men, fresh food, dynamite, drill-hole casing and fuel to jungle-bound camps. Sick workers can be flown out quickly and replacements flown in. The ground party chief travels by " whirly bird " to control and supervise work. A few minutes flying enables him to visit several groups engaged on cutting trails, drilling or seismic shooting. As water often provides the only landing space, the helicopters operate on floats for much of the time. They can carry light aluminium canoes for use if required.

Shell Condor's field force found the Magdalena River a formidable obstacle. In order to continue the development of the Yarigui oilfield, through which the Magdalena flows, it was necessary to build a drilling location, Yarigui 3, on one of the islands in the river. This was a risky undertaking because of the strong water current and the unpredictable nature of the river which, when in flood, can sweep whole islands and sand-bars downstream.

Hardly had drilling begun when a change in current caused rapid erosion of the river bank. A barrier of old oilfield pipes was raised against the swirling waters, and later a protective rock groyne; but something more permanent was needed. The old Netherlands " Dutch mat " system of protecting river banks and dykes was used. A raft 50 ft by 80 ft and about 2 ft thick, made of brushwood and covered with a rock layer, was sunk into position and the projecting level topped by a smooth surface of gravel sand. Wooden fences pegged firmly into the underlying raft prevented the stones from slipping.

Yarigui 3 was safe and oil could be brought up from beneath the tricky waters of the Magdalena. This method of protecting drilling sites from the river is being watched with great interest.

Under the Midnight Sun

The Yukon, in the Northwest Territories, Canada, famous since, gold rush times, are again a happy hunting ground for explorers. This time oil is the " liquid gold " being sought.

In the short northern summer of 1958, Shell Oil Company of Canada mapping parties recorded nearly 70,000 square miles of territory, stretching north from the oil-rich province of Alberta. Six field parties were sent from the base camp, East 3, 120 miles north of the Arctic

On an island site in the Magdalena River, Colombia.

Circle, to explore three areas: the Franklin Mountains area lying west midway between Great Slave Lake and Great Bear Lake; an area east of the Mackenzie River Delta; and in the Richardson Mountains, in the most north-west corner of Canada.

Each party consisted of a geologist, an engineer, a student geologist and a cook. In addition a helicopter pilot was attached to each party for, in this rugged territory, air travel enables geologists to cover several times as much territory as by horse, canoe or motorboat. Help was also given by a Dakota, primarily in flying provisions from Edmonton (Alberta) to the East 3 base camp, and two Otter aircraft which supplied the party camps. Radio communications were set up between base, the camps, and the shell aircraft and helicopters. A portable laboratory, installed at East 3 base camp, sent back technical reports on samples and information collected in the field.

With the autumn and the onset of the winter freeze-up came the seismic and test drilling crews with tracked vehicles to probe the likely areas. Only in winter are the peat-bog "muskeg" areas firm enough to support the heavy equipment.

Under the muskeg there may be oil. If working conditions are exceptionally hard, it means that the oil will take that much longer to find. After that it will have to be got out and back to the user areas.

Offshore Hazards

Searching for oil on land can be difficult enough, but when the seas and oceans have to be explored, the problems grow in size and complexity. Costs are trebled and weather hazards can bring disaster.

In 1953 the Shell Company of Qatar Limited (then the Shell Overseas Exploration Company) began operations in a 10,000 square mile marine concession in the Persian Gulf. First came 18 months of gravimetric and seismic surveys to determine where to drill with the best chance of success. These operations involved the use of a 4,000 ton depot ship, a small fleet of launches, and short-wave shore stations for sending out the signals required for the navigating system which determined the exact position of the survey launches.

The second stage, exploratory drilling, began in late 1954 with the erection of a 1,200 ton movable steel island at a cost of £900,000. The platform was used at two locations, both of which proved unsuccessful. Then disaster struck. As the platform was about to be towed to shore for modification a violent storm developed, wrecking the platform and halting drilling —after an outlay of £7 million without finding oil.

Oil *has* been won from below the seabed in other parts of the world. Preparations for further exploration at Qatar are going ahead.

Among the Sand

The sands of the Sahara, dry and inhospitable, are becoming more and more important in world affairs. These vast wastes contain great mineral wealth, including oil.

Six years of arduous search in the desolate southern territories of the French Sahara have already tapped rich oil and gas deposits. By 1960 or 1961 it is estimated that total output may be some 8 million tons yearly, rising to between 25 and 30 million tons by 1965.

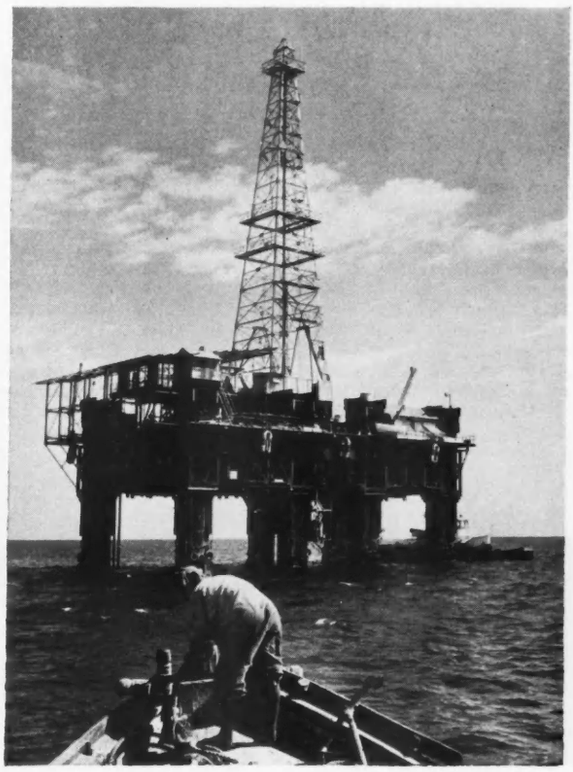
The initial discovery of Saharan oil was made by the Compagnie de Recherches et d'Exploitation de Petrole au Sahara in the Edjele field, close to the Libyan frontier. This success was followed at two more fields. The producible reserves of the three have been tentatively estimated at some 100 million tons, and CREPS has also located reserves of gas.

Striking successes elsewhere have been made by other French interests, notably the vast Hassi R'Mel gas field and the Hassi Messaoud oilfield, and oil is already reaching France from Hassi Messaoud. Many oil companies and associations of companies are taking part in the search, including Compagnie des Petroles d'Algerie, which has exploration permits covering some 30,000 square miles.

The Sahara geophysical survey and test drilling crews lead a spartan life. Distances covered are vast, air and radio communications essential, and new roads have to be made to take the heavy wheeled vehicles needed for the job. Water points are far apart, and extremes of climate and squally, desert winds have to be endured. Drilling is carried out all the year round, even during the full summer heat which is frequently 120° in the shade.

Up to September of last year, 33 exploration wells and a number of coreholes had been drilled by CPA crews; the total expenditure had grown to about £17 million. So far, no oil has been found, but the seismic explosions continue and new test wells are still being sunk. For the oil industry can make the desert bloom; their cultivating tools are in the geologist's hammer, the seismic record, and the drill.

Stories like these can be culled from the records of oil companies everywhere. A new oilfield is a stake in the future; yet another assurance that the oil will be available to meet the world's rising energy needs. That is why the search is being intensified in remote regions, why the drills probe deeper than ever before, and why natural obstacles, however difficult, are being overcome. For the oil industry of today is keenly aware of its responsibility to tomorrow.



In the Persian Gulf. The " island " was later wrecked in a storm.

In the heat of the Sahara.

In the cold of Alberta, Canada.

Design

STEAM POWER *for* UNDERDEVELOPED COUNTRIES

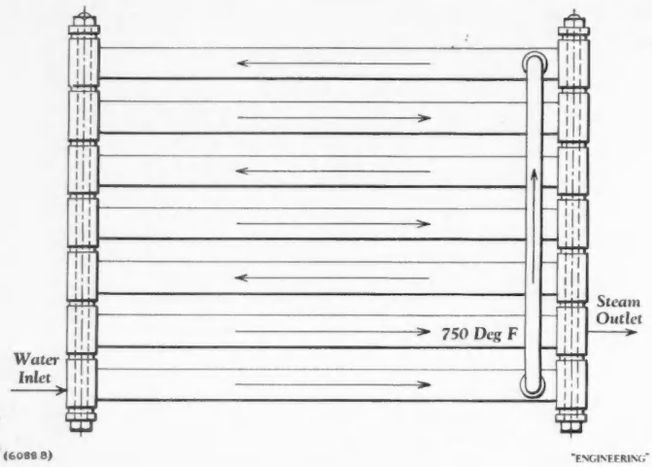
WITHOUT a simple source of mechanical power, there is a little possibility for underdeveloped territories to raise their standard of living. Many such areas have no ready access to liquid fuel supplies and cannot therefore utilise the combustion engine. A solution to the problem would be a simple, safe steam power unit, suitable for operation by unskilled native labour and which could use local water supplies and local solid fuels—low grade coal, wood, cotton waste, or dung. Such a plant has, during the past three years, been under intensive development by E. Reader and Sons Limited, Phoenix Works, Nottingham, and has successfully withstood the most abusive treatment, such as heating the dry boiler to red heat and then injecting feed water. Only after continued maltreatment of this sort has serious deterioration resulted.

The Reader steam power unit, shown in the accompanying illustration, is a robust assembly comprising a steam generator, designed to ensure rapid steaming without explosion danger, and a slightly modified standard Reader single-cylinder engine, well-proved and requiring the minimum of attention. The whole unit weighs 2,912 lb and occupies a floor space of 5 ft by 2 ft 7 in, with an overall height (including 3 ft stack) of 9 ft. It can be readily dismantled for transport, and it can also be supplied in the form of a wheeled vehicle. Boiler and feed water pumps are automatic, and the control gear regulating the water feed and supply is of a straightforward mechanical type.

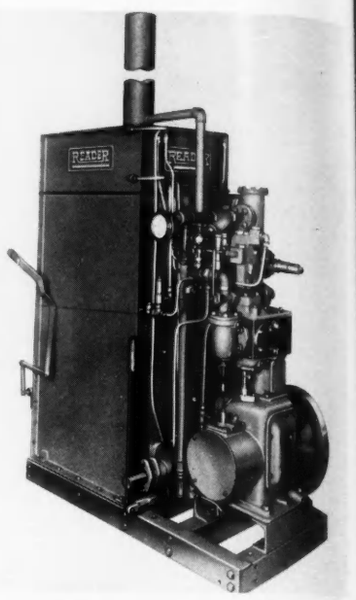
The steam generator is intended to handle muddy river water, and the boiler units can be readily taken to pieces for cleaning, since it may be impossible to strain out all fine suspended solids. From the river, water is pumped through a foot valve and primary strainer and thence through a fine gauze strainer into the suction side of the water pump, from whence it is delivered through a ball-float valve into the intake compartment of a two-compartment feed tank, in which the solids settle. The second compartment, from which the boiler feed is drawn, is filled by way of a V-notch in the bulkhead between the two feed tank compartments. Again, there is a fine gauze strainer in the boiler feed pump suction line. The V-notch arrangement ensures that there is a reserve of water in the intake compartment for initially charging the steam generator when starting up the boiler; a hand pump being used for this purpose.

The steam generator is essentially a monotube boiler, built up from a bank of interchangeable elements, as indicated in the accompanying illustrations. Each tubular element is fitted with a core plug. This ensures that only a small quantity of water (10 pints) circulates through the boiler, thus minimising the risk of explosion damage; yet at the same time adequate heating surface is provided for quickly raising steam. As may be seen, the tubular elements are readily dismantled for cleaning, the sidewall of the generator having been removed previously. The firebox is of steel plate, lined with refractory.

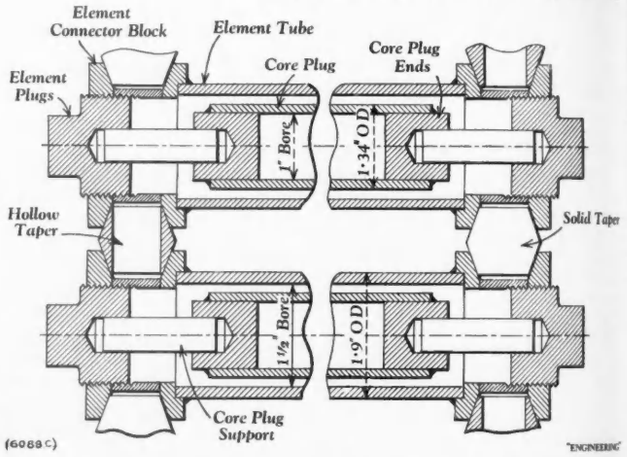
From the steam generator the steam passes by way of a temperature control regulator and—if necessary—a desuperheater, through a safety valve and a steam strainer to the engine.



Arrangement of monotube boiler.



The Reader steam power unit is intended for safe reliable operation by unskilled natives.



Diagrammatic section through adjacent boiler elements.

The totally-enclosed single-cylinder double-acting engine develops 5-6 h.p. at the normal running speed of 450 r.p.m., and working pressure 120 lb per sq. in, but an intermittent overload of 7-8 h.p. can be attained. A governor ensures close speed regulation. The flywheel incorporates a driving pulley, and the valve mechanism is arranged to allow the direction of rotation to be reversed, if desired. Splash lubrication is employed, and the oil consumption is said to be negligible. The piston rod gland is self-adjusting, and the entry of water into the crank chamber is relatively small; any water which does collect is automatically drained off.

Among the duties for which the steam power unit is suitable, are such applications as corn grinding mills, chaff cutters, winnowing machines, small threshing machines, rice hullers, oil presses, cane mills, decorticating plant, and irrigation. The 5 h.p. engine would be sufficient to pump approximately 10,000 gallons of water an hour, assuming nominal suction and discharge head. A circular saw could be easily driven, or power supplied to a workshop having a 12 in lathe, drilling machine, or other equipment. On a tropical estate, the unit could provide power and lighting requirements, and supply both hot and cold water services.

NYLON SEALS FOR HYDRAULIC RAILWAY BUFFERS

Air and oil-filled hydraulic railway buffers present a difficult problem in choice of material for making the seal which must be provided between the moving piston and its housing, and which must cope with the high pressures produced during impact on the buffer.

ICI Plastics Division's "Maranyl" nylon has solved this problem for Oleo Pneumatics Limited, Kenilworth, whose oil-filled pneumatic buffers are now fitted as standard equipment on diesel railcars and on some passenger and freight rolling stock.

A specially shaped nylon-lipped seal, expanded against the cylinder bore, has been developed. The nylon seal operates against a polished chromium-plated metal surface where the excellent abrasion-resistance of the nylon is of considerable importance. The seal is backed by a nylon bearing between the piston and its housing, and at the opposite end a nylon bush constitutes the front bearing.

Inspection during service is confined to visual examination for mechanical damage, wear of buffer head and length of buffer spindle exposed. No filler plug is provided, but instead adequate reserves of oil and air are initially provided to cater for any slight losses during each five-year service period.

500 TON STATIC *and* FATIGUE TESTING MACHINE

At the Laboratories of the Secretaria de Comunicaciones y Obras Publicas in Mexico City a 500 tons (metric) Amsler universal testing machine has recently been installed.

The size and strength of specimens to be investigated for the Ministry of Traffic and Public Works determined the dimensions of the machine, which was built accordingly with a maximum distance of 7 metres between the slotted clamping platens and a clearance of 1·2 metres between uprights. The overall height of the machine is 14 metres, of which only 8·8 metres are above the floor, as can be seen in the upper illustration, which shows the machine receiving final adjustments.

A scale model of the whole machine is shown in the centre column. It is believed to be the first vertical testing machine of this size and capacity operating on the " one-space " principle—which means that the same space is used for tensile and compression (also transverse) tests. Provided that a suitable gripping device is used, therefore, the specimen can be alternately stressed in tension and compression without changing its place in the machine. In hydraulic testing machines of conventional design, the working ram moves in one direction only, displacing a crosshead. Between this and one end of the machine frame tensile specimens are tested, compression specimens being introduced between the opposite end of the frame and the crosshead. The advantages of the " one-space " machine are obvious, especially in the case of bulky and heavy specimens and when, as in this case, the lower boundary of the testing space is made to lie at floor level.

PLATEN ARRANGEMENTS

In the machine described, the bottom clamping platen is at floor level in the no-load condition; it can move upwards for compression and downwards for tension. In order to give maximum stability to the machine, the bottom clamping platen is guided at its four corners by means of adjustable rollers bearing against machined surfaces on the uprights; the platen is also connected by stiff braces to two tubular structures which enclose the working cylinders and are guided by adjustable rollers bearing against the outer surface of these cylinders. Thus the bottom clamping platen is prevented from tilting even if the arrangement of the specimen produces a significant eccentricity of load.

Two vertical working cylinders, arranged back to back, are provided. The bottom clamping platen being rigidly guided, no rigid connection can be used between this platen and the working rams, as a slight lateral clearance in the guiding mechanism must be present to make possible movement at all. Even this very small clearance would be sufficient, however, under eccentric load, to cause edging of the rams with the very close fit used between them and their cylinders. The hydraulically-produced load is therefore transmitted from the rams to the guiding frame by means of articulated stilts of a special design, the latter permitting movement in all directions practically without friction, even under maximum load. Ram strokes are 0·5 metres in both directions from the neutral position.

The top clamping platen is carried on a crosshead and is fixed to the uprights at a convenient height by means of shear-bolts. It is moved along the uprights by means of a lift, which serves also as a working platform. Push-button controls of the electric winch situated at the top of the machine are provided for operation from the floor or from the platform itself. At each of the four corners of the crosshead, three permanently mounted bolts are provided, one only of each group being engaged with the uprights at a time. The uprights are welded box girders with holes for the shear-bolts on their flanges. The bolts, when actuated by a suitable ratchet wrench, move axially, entering or withdrawing from the holes. The spacing of the holes and of the three levels of bolts is chosen in such a way that the crosshead can be fixed at the desired height in increments of 25 cm.

The working platform, besides positioning of the crosshead, is used for inspection of the specimen during the test, for setting instruments, for making measurements, etc. Sections of the platform floor can be lifted like trapdoors, so as to permit testing of specimens, such as experimental walls, which are long in the direction perpendicular to the plane defined by the vertical axes of the uprights.

Specimens with flanged ends can be bolted directly to the slotted clamping platens. For other specimens conventional gripping means are provided, which in their turn are bolted down. The grips can be rolled into the machine on a low platform on rail-guided wheels; the top grip is then bolted to the crosshead, or rather the top clamping platen, and raised to the desired height. The bottom grip can then be rolled out again and, for compression tests, the specimen can be positioned on it, or, in the case of masonry, even be built directly upon it, outside the machine. When ready, the specimen is rolled into the machine, the bottom grip bolted to the bottom clamping platen and the top grip lowered on the specimen.

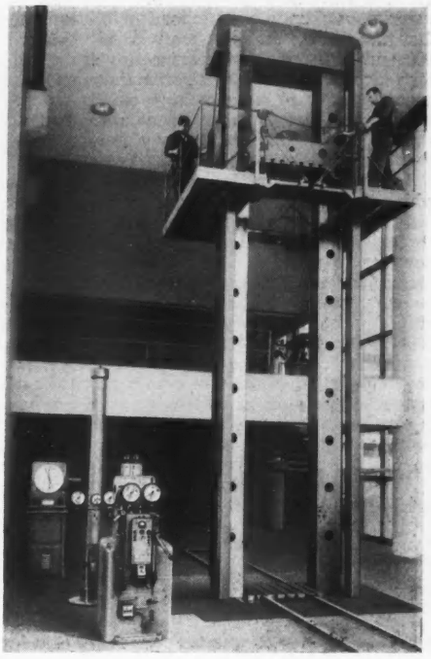
When a long specimen is presented in the horizontal position, one end can be put on the rolling platform, the other end fastened to the lowered top grip. By lifting the working platform and the crosshead with it, the specimen is pulled upright and into the machine and is, after centring and eventually clamping, ready for test. When compared with the design of conventional machines in the " million-pounds " range, the ease and convenience in the handling of heavy specimens will be appreciated.

LOAD MEASUREMENT

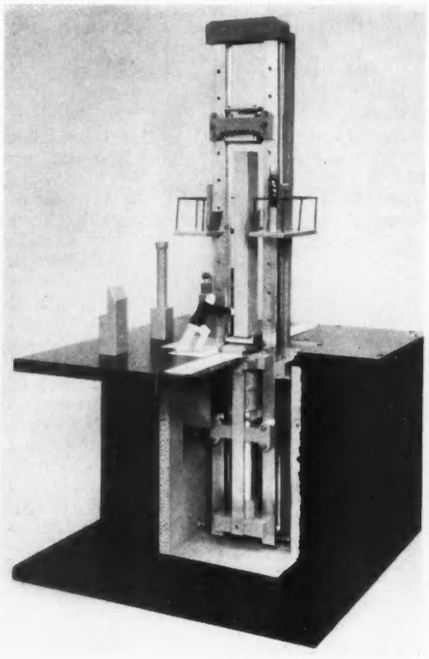
The machine can be equipped with a number of standard gripping devices, such as spherically seated compression platens, 80 by 80 cm; wedge grips for round bars up to 85 mm diameter and for flat bars up to 60 by 115 mm; buckling platens, which can freely tilt in all directions even under load; beams for transverse tests and for compression and buckling tests on broad specimens, such as walls, etc.

Test loads are produced hydraulically and measured by the familiar pendulum dynamometer; the latter contains also the high-pressure oil-pump and its driving motor. Four load-ranges are provided: 500, 250, 100 and 50 tons, with a guaranteed accuracy within $\pm$ 1 per cent of the indicated load in the upper nine-tenths of each load range. The considerable weight of the moving parts of the machine (rams, guide-frame, bottom clamping platen and grips) as well as of the specimen, is compensated for by a separate hydraulic system, so that no special setting of the load indicator is necessary, the latter always showing the net test load.

The machine is believed to be the first, and at present the only one of its capacity, which is equipped for regular fluctuating-stress fatigue tests with nearly sinusoidal variation of the load at 250 cycles per minute. The maximum load amplitude is 100 tons in tension or in compression



500 ton universal static and fatigue testing machine during final adjustments at the Laboratories of the Ministry of Traffic and Public Works at Mexico City. From left to right: pendulum dynamometer, pneumatic-hydraulic accumulator, and Pulsator. Auxiliary hydraulic systems are below floor level.



Scale model of the 500 ton machine, showing the tubular guides and the braces for the bottom clamping platen. A tall compression specimen is being pushed into the testing position.

Continuing **Design**

with a load limit of 200 tons in either direction. Thus, a fluctuating load of 100 tons can be superimposed upon a static load of 100 tons, so that the load on the specimen will vary between 100 and 200 tons. Civil engineering structures, for which this machine was particularly designed, generally have to support large steady stresses due to their own weight and fluctuating working stresses, which are usually only a fraction of the former.

The well known hydraulic Pulsator, with which the machine is equipped for these fatigue tests, works on the principle of periodically forcing an additional quantity of oil into the working cylinder of the machine, thereby increasing the pressure to the desired value. In conventional hydraulic fatigue testing machines it is customary to use the same ram section for static and for dynamic testing. In a machine of the size described, however, the working section of the ram is so big that the oil output of a standard Pulsator would produce a very small dynamic stroke only, and would not always be sufficient to strain the specimen enough to obtain the desired peak load.

The rams and cylinders of the present machine are, therefore, of a special design, each provided with two working sections. This is achieved by reducing the diameter of the back end of each ram and cylinder. A smaller circular and a bigger annular section results, each of which can be put under hydraulic pressure independently.

For static tests the bigger annular section only is used; the smaller circular section is connected to the Pulsator for dynamic (fatigue) tests. During the latter, the steady part of the test load (the minimum load) is maintained by putting the annular section under pressure and holding the latter at a constant value by means of a pneumatic-hydraulic accumulator. This consists mainly of a pressure vessel, partly filled with nitrogen and partly with oil. The pressure of the nitrogen changes only slightly when, due to the movement of the ram under the influence of the Pulsator, the oil level in the accumulator fluctuates. The resulting variations of the steady load are usually negligible; they can be measured, however, and taken into account when determining the load limits on the specimen with very high precision. A separate pump, automatically controlled by a pressure-sensitive device, maintains the pressure in the accumulator constant by compensating for any losses of oil in the system.

The Pulsator being connected to the smaller circular section of the ram, a given oil output produces a longer dynamic ram-stroke than it would if acting upon the bigger annular section. Thus one standard Pulsator with a maximum output of 300 cu. cm per stroke is usually sufficient for producing a fluctuating load up to 100 tons. If specimens with an exceptionally low overall modulus of elasticity are to be tested, the need may arise to couple two standard Pulsators and thus to double the oil output per stroke.

The design of the machine is also very favourable to precision in fatigue tests, as the moving masses have been reduced to the minimum. The reciprocating movement is, in fact, confined to the rams, the stilts, the guiding frame and the bottom clamping platen with the bottom grips, if any. The mass of the specimen is taken care of by the previously mentioned auxiliary compensation system. The reduction of the moving masses is very important, as their accelerations and decelerations during each load cycle produce additional inertia-loads on the specimen, which are not shown by the dynamic load indicators and have to be calculated. These inertia loads should be as small a fraction of the hydraulically produced fluctuating load as possible.

The new machine, which was built by Alfred J. Amsler and Company, Schaffhausen, Switzerland shows that there are still considerable possibilities of improvement in materials testing machines.

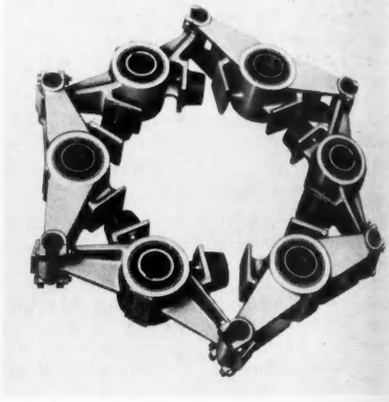
TORQUE TRANSFER COUPLING *for* MARINE DRIVE

To solve the problem of resonant torsional vibration in the marine engine/propeller-shaft system, a new torque transfer coupling has been developed by Metalastik Limited, Leicester. The coupling provides initially a very low stiffness, with a much higher value after a predetermined torque is reached. The ratio of initial to final stiffness can be varied as required. For the particular design illustrated it is about 1 to 9, but lower as well as higher ratios are possible. This is due to the fact that for low torques, rubber loaded in torsional shear is employed while for higher torques separate rubber buffers, loaded in compression, provide the higher stiffness required. In addition to its capacity to damp torsional vibrations the coupling accommodates some mal-alignment.

In view of the torque transmitted and the torsional flexibility provided, the torque transfer coupling is a very compact device. The coupling illustrated has a diameter of only 45 in, and is $7\frac{1}{2}$ in wide. It is fitted between the flywheel and gearbox of a marine diesel engine developing 1,000 b.h.p. at 435 r.p.m. At 6,000 lb-ft torque, the torsional deflection is $7\frac{3}{4}°$. The design is suitable for drives of 500 to 1,000 b.h.p. at 435 r.p.m. or equivalent torques at speeds up to 500 r.p.m.

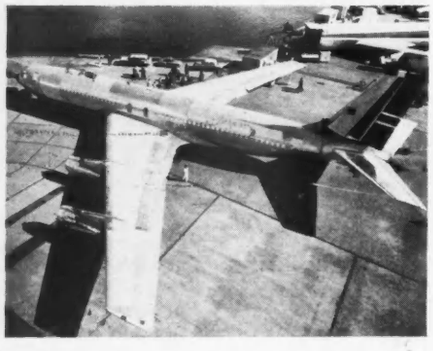
Basically the coupling consists of two sets of three rocker arms. They are connected at their extremities by Metalastik Ultra-Duty shackle pins. Each arm pivots centrally on a Metalastik Ultra-Duty bush. One set of rockers is connected by three tapered pins to the flywheel and the other set by three pins to the gearbox flange, the inner sleeves of the centre pivot bushes being keyed to the pins. Rubber bonded buffers are bolted to flats formed on three of the rocker arms. The buffers come into contact with flats on the other set of rockers when a certain torque has been reached and the initial clearance has been taken up.

The Metalastik torque transfer coupling is being fitted to new Ruston and Hornsby marine diesel engines and is manufactured to Lloyd's requirements. It is to be on view at the forthcoming Engineering, Marine, Welding and Nuclear Energy Exhibition at Olympia.



The torque transfer coupling provides initially a very low stiffness, but after a given torque, the rubber buffers come into contact with the flats, giving a much higher stiffness.

BOAC'S FIRST 707



Boeing 707 Intercontinental jet airliner.

The first Boeing 707 Intercontinental jet airliner for British Overseas Airways Corporation is shown as it rolled out of the Boeing Airplane Company Transport Division plant in Renton, Washington, recently—the 35th 707 to come from the factory.

The Intercontinental has four Rolls-Royce Conway by-pass jet engines, and the aircraft will make its initial flight later this spring. It will then be based at the Boeing Flight Centre in Seattle for Federal Aviation Agency certification tests. The first of BOAC's 15 Boeing 707 Intercontinentals will be delivered to the airline late this year. Capable of carrying up to 189 passengers in economy-class accommodations, the 311,000 lb Boeing will cruise at speeds up to 605 m.p.h. With full payload of 45,000 lb, it will operate non-stop across the North Atlantic.

STEAM PLUS GAS TURBINE

For Navy Frigates

The Admiralty have announced that certain guided missile destroyers and general frigates are to have an advanced form of propulsion which will consist of a steam turbine together with a gas turbine, geared to the same propeller shaft. Ships so equipped will be ready to leave port at any time without first raising steam.

HMS Ashanti, the general service frigate built by Yarrow and Company Limited at their Scotstoun yard, was launched on 9 March. She is the first of the Navy's ships to be equipped with this method of propulsion. The whole of the propulsion machinery, steam turbines, gas turbines and gears, has been supplied by the turbine-generator division of Associated Electrical Industries, Trafford Park, Manchester.

Marketing

More Sales to Russia

The Russian market for British capital goods is developing at a greater pace than at any time since the war. The large orders placed for rubber and tyre making plant with the consortium of British companies Rustyfa, for process plant with Vickers and the beginning of orders for special machine tools have now been followed by an initial contract for £½ million for specialised precast cement plant with the Dowsett Group: "considerable further business is expected."

In their announcement Dowsett—whose chairman is Field-Marshal Sir Claude Auchinleck and deputy-chairman Sir Toby Low—said that negotiations started some time ago on the technical requirements of the Ministries of Electrico Power Stations, Railways and Transport Construction, in connection with the usage of the "Dow-Mac Process" for the manufacture of pre-stressed precast concrete units and the associated specialised machinery as developed by Dow-Mac (Products) Limited. Final negotiations took place in Moscow with V/O Technopromimport to settle the contract and the technical appendices. Delivery of technical information will commence during the middle of this year to be followed by plant deliveries. The contract will be completed by the end of 1960. Firm inquiries for expansion of the present work have already been received by Dow-Mac. Mr. Harry Dowsett, managing director of Dowsett Holdings, and Mr. W. K. Roberts, managing director of Dow-Mac, visited several sections of the Soviet concrete industry in 1957, in the Moscow area, the Ukraine and on the Black Sea coast. Many specialists of the Russian concrete industry have visited the factories of Dow-Mac. They were evidently attracted by the fact that Dow-Mac are leaders in this field and have developed their process to include a wide range of prestressed pre-cast units, such as railway sleepers, sheet and bearing piles to 35 metre lengths, bridge beams and members for heavy industrial buildings, such as power stations.

It was Mr. Dowsett who, in 1954, successfully negotiated a contract worth £7 million for the supply of 20 trawlers for the USSR by Brooke Marine Limited, another associated company in the Dowsett Group.

Egypt Opens Up

The first order for plant for Egypt to be reported since the signing of the Anglo-Egyptian Financial Agreement has been won by Gardners. They have signed a contract for 34 of their marine diesel engines, complete with installation accessories and sterngear, for use in trading craft operating in the Nile Delta and the Red Sea.

The company report that further orders are now being negotiated and it would appear that the relationship which existed before the Suez crisis between the company and Egypt has been fully restored. Another order placed by Egypt recently was for the construction of three pipelines for the internal transportation of fuel supplies. The contract, worth over £5 million, has been awarded to the Mannesmann Company of West Germany. The terms on which it was secured are interesting: a 12½ per cent payment will be made in advance in the form of cotton and the balance over eight years at 5 per cent interest.

Anglo-American Selling

The British Petroleum Company and the Sinclair Oil Corporation have recently announced the formation of a jointly-owned selling company, Sinclair and BP Sales, Inc., which will be concerned with the distribution of Middle Eastern and Venezuelan crudes in the Western Hemisphere.

Mr. Carl G. Drescher, formerly vice-president of Sinclair Oil, has been elected president of the new company, and Mr. R. D. Hill, formerly operations manager of BP Trading, has been elected senior vice-president.

Cummins Return Flow

Less than two years after Cummins established manufacturing facilities for their range of heavy duty diesel engines in this country some British-made engines are being sold in North America. This follows the usual pattern when an American firm begins to manufacture in Europe products with a high labour content.

The first quantity shipment of British-made Cummins diesels arrived in Canada earlier last month. Announcing this, the company's sales vice-president, Mr. C. R. Boll, explained that this would enable Canadian manufacturers of trucks and mining equipment to increase the Commonwealth content of their imports. He pointed out that components of British-built engines are interchangeable with American-built models and can utilise fully the large stocks of repair parts existing in Canada.

The engines will be used to power "on-highway" trucks of the White Motor Company, Toronto, and Canadian-Kenworth, Vancouver. British-built Cummins engines now power the trucks of five Canadian manufacturers. Engines are also being supplied to International Harvester for their 19 ton and 27 ton "off-highway" haulage equipment for construction and mining applications.

Mr. Boll was of the opinion that there would be "a tremendous growth" in Canada of demand for heavy trucks, and for construction and mining equipment, which are key industries requiring diesel power.

Electronic Enterprise

A most unusual undertaking took place last month (March) in the selling of space at an international exhibition. Three men toured the instrument and electronics centres of Europe with a vanload of display material in order to persuade manufacturers to exhibit at the International Instruments, Electronics and Automation exhibition of 1960. All three are representatives of the exhibition committee whose task it is to promote the IEA at Olympia. The team leader, Mr. Charles Hanrott, is chairman of the committee (on which six trade associations are represented) and his colleagues, Mr. "Ted" Rees and Mr. Eric Hart, are directors of Industrial Exhibitions Limited, the IEA organisers.

In little more than two weeks they visited Denmark, Italy, Germany, France and other countries where there are important manufacturers of instruments and electronic equipment. They went with the blessing of the Board of Trade, and the following message from the president, Sir David Eccles: "Please tell our European friends that we shall welcome them, that we shall hope to learn something from them, and that we believe they will have something of value to learn from us." The 1958 exhibition attracted 60,000 visitors including 3,000 buyers from 83 foreign countries. It is the largest of its kind in the world.

Crucibles by Condor

A fine tribute to the London Midland Region of British Railways by the Morgan Crucible Company: "Always anxious to improve deliveries," they said, "Morgans climbed aboard the new express freight train—the Condor—running between London and Glasgow with deliveries of crucibles to customers in Scotland." The containers are collected from Battersea Works during the afternoon and delivered in the Glasgow area the following morning, having tavelled through the night at express train speeds (400 miles in 10 hours).

This kind of door-to-door overnight collection-delivery service cannot be matched by any kind of road transport. In Morgan's own words, "the door-to-door container service will cut down the time factor, thereby improving delivery and also the relationship between customer and manufacturer—producing in fact a satisfied customer.

ISMAon Price Reduction

A conference to find ways in which firms can maximise profits by reducing prices is being planned by the Incorporated Sales Managers' Association to be held at Torquay from 8 to 12 May.

Plans include showing a British Productivity Council film on variety reduction, and a brains trust of top executives from leading firms in the main sectors of industry. The purpose of these is to help firms with revision of production and marketing policies to facilitate simplification of manufacture which a policy of higher profits through lower prices entails. In a written message to the Association's 6,000 members, Mr. D. R. Griffiths, the director, has warned that under a government policy of full employment and price stability it may become impossible to maintain profits at existing prices. The alternative is to bring down prices, standardise production and find ways of increasing demand and widening markets.

Selling to Japan

The value of Japan as a market for specialised British equipment tends to be underestimated. Perhaps this is due to the popular conception of Japan as the ubiquitous cut-price competitor. This is far from the truth. Japanese industry cannot compete effectively when they have no home market, nor can they produce know-how and designing skills out of a hat. The proof of this is that they spend a great deal of money buying their requirements of special plant.

Humphreys and Glasgow have won their second contract to build a plant using the Onia-Gegi catalytic oil-gas process for the production of gas from heavy fuel oil. It will be built at the Himeji works of the Tokyo Shibura Electric Company (Toshiba), 150 miles from Japan's first Onia-Gegi plant which is being built at Yaizu. Catalyst and special equipment, such as pneumatic and hydraulic control gear, will be supplied from the United Kingdom. The rest of the plant will be made in Japan by Humphreys and Glasgow's licensees, Ishii Iron Works Limited.

MEETINGS AND PAPERS

British Computer Society

LONDON
"The Mechanical Translation of Languages," by Professor L. Hobgen. Northampton College of Advanced Technology, St. John Street, EC1. Thurs., 16 April, 6.15 p.m.*

British Institution of Radio Engineers

LONDON
Symposium on "Large Capacity Storage Devices." Computer Group. London School of Hygiene and Tropical Medicine, Keppel Street, WC1. Mon., 6 April, 3 p.m. and 6 p.m.
NEWCASTLE UPON TYNE
"Radio Exploration of the Galaxy," by Dr. J. Baldwin. North Eastern Section. Neville Hall, Westgate Road, Newcastle upon Tyne. Wed., 8 April, 6 p.m.

Building Centre

LONDON
Film Display: "Major Road Ahead" (London-to-Birmingham Motorway), exhibited by John Laing and Son, Ltd. Wed., 8 April, 12.45 p.m.

Chemical Engineering Group

BIRMINGHAM
"Electrical Engineering in the Chemical Industry," by D. Birch. Birmingham College of Technology, Suffolk Street, Birmingham 1. Wed., 15 April, 6.30 p.m.

Chemical Society

LONDON
Annual General Meeting, at 9.30 a.m. Presidential Address on "Some Inorganic Polymers," by Professor H. J. Emeléus, at 10.30 a.m. Friends House, Euston Road, NW1. Wed., 8 April.

East Midlands Metallurgical Society

NOTTINGHAM
Annual General Meeting. "Metallurgical Examination of Failures," by G. A. Cottell. Electricity Demonstration Theatre, Carrington Street, Nottingham. Tues., 7 April, 7.30 p.m.

Engineers' Guild

LONDON
Luncheon Meeting. Metropolitan Branch. Constitutional Club, Northumberland Avenue, SW1. Wed., 8 April, 12.20 for 12.50 p.m.
EDINBURGH
Luncheon Meeting. "Town and Country Planning," by J. McGuiness. East of Scotland Branch. Scottish Liberal Club, 109 Princes Street, Edinburgh. Mon., 6 April, 12.45 for 1 p.m.

Helicopter Association

LONDON
"French Helicopter Developments," by L. F. G. Legrand. Royal Aeronautical Society, 4 Hamilton Place, W1. Fri., 10 April, 6 p.m.

Illuminating Engineering Society

LEEDS
Annual General Meeting. Leeds Centre. Guildford Hotel, Leeds. Mon., 6 April, 6.15 p.m.
MANCHESTER
Annual General Meeting. "Son et Lumière in Great Britain," by H. Hewitt. Manchester Centre. Green Room Theatre, Cheapside, off Cross Street, Manchester 2. Thurs., 9 April, 6 p.m.

Institute of Marine Engineers

BIRMINGHAM
"Heavy Oil Burning," by Dr. J. S. Clarke and G. J. Hudson. West Midlands Section. Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham. Thurs., 9 April, 7 p.m.

Institute of Metals

LONDON
Annual General Meeting. London Local Section. Thurs., 9 April, 6.30 p.m.*
OXFORD
Annual General Meeting. Coloquium on "Modern Joining Techniques: (*a*) Electron Bombardment; (*b*) Ultrasonic Applications; and (*c*) Non-Metallic Bonding." Oxford Local Section. Cadena Café, Cornmarket Street, Oxford. Tues., 7 April, 7 p.m.

Institution of British Agricultural Engineers

LONDON
"Measurement of Crop Drier Performance," by P. H. Bailey. Tues., 14 April, 2.15 p.m.

Institution of Chemical Engineers

CHESTER
"High Vacuum Technology in the Chemical Industry," by A. S. D. Barrett and T. W. G. Rowe. North Western Branch. Blossoms Hotel, Chester. Wed., 15 April, 7.30 p.m.

Institution of Civil Engineers

LONDON
"Economics of Framed Structures," by L. R. Creasy. Tues., 7 April, 5.30 p.m.*
BIRMINGHAM
Open Meeting. Midlands Association. James Watt Memorial Institute, Great Charles Street, Birmingham. Thurs., 9 April, 6 p.m.
EDINBURGH
Annual General Meeting and Film Display. Edinburgh and East of Scotland Association. North British Hotel, Edinburgh. Wed., 8 April, 6 p.m.

Institution of Electrical Engineers

LONDON
Discussion on "Co-operation Between the Electricity and Gas Industries," opened by F. C. Smith. Mon., 6 April, 5.30 p.m.*
"An Electron Trajectory Tracer for Use with the Resistance Network Analogue," by M. E. Haine and J. Vine. Measurement and Control Section. Tues., 7 April, 5.30 p.m.*
"The New Post Office 700-Type Telephone," by F. E. Williams and F. C. Carter; and "The Design of an Automatic Sensitivity Control for a New Subscriber's Telephone Set—The British Post Office 700-Type Telephone," by F. A. Wilson. Radio and Telecommunication Section. Wed., 8 April, 5.30 p.m.*
Discussions on "Problems of Sight, Hearing and Touch," opened by Professor E. C. Cherry; and "Human Engineering Recording Problems," opened by H. C. W. Stockbridge. Medical Electronics Discussion Group. Fri., 10 April, 6 p.m.*
BIRMINGHAM
Papers on the provision of adequate electrical installations: "In Multi-Storey Flats and Maisonettes," by C. A. Belcher; and "In Houses," by C. C. Hyams. South Midland Centre. College of Technology, Gosta Green, Birmingham. Mon., 6 April, 6 p.m.*
EDINBURGH
"Recent Advances in Speed-Changing Motors," by Professor G. H. Rawcliffe. South East Scotland Sub-Centre. Carlton Hotel, North Bridge, Edinburgh. Tues., 7 April, 7 p.m.
HULL
"Electrical Installations of the Royal Aircraft Establishment High-Speed Wind Tunnel at Bedford," by P. McKearney, L. S. Drake and E. G. Mallalieu. North Midland Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Thurs., 9 April, 6.30 p.m.
LIVERPOOL
Annual General Meeting. "Artificial Fibres," by Dr. P. T. Standring. Mersey and North Wales Centre. Royal Institution, Colquitt Street, Liverpool. Mon., 6 April, 6.30 p.m.
MANCHESTER
"High-Voltage D.C. Transmission, with Special Reference to the Cross Channel Cable," by F. J. Lane. North Western Centre. Engineers' Club, Albert Square, Manchester. Tues., 7 April, 6.15 p.m.
NOTTINGHAM
"Subscriber Trunk Dialling," by D. A. Barron. East Midland Centre. College of Arts and Crafts, Nottingham. Tues., 7 April, 6.30 p.m.*
PORTSMOUTH
"Rockets and Satellites," by Dr. R. L. F. Boyd. Southern Centre. Offices of the Southern Electricity Board, Drayton, Portsmouth. Wed., 8 April, 6.30 p.m.*
YORK
"Relation Between Picture Size, Viewing Distance and Picture Quality," by L. C. Jesty. North Midland Centre. Royal Station Hotel, York. Tues., 7 April, 7 p.m.

Institution of Electronics

BIRMINGHAM
"Electronics in Industry, Including Computer Applications," by J. S. Evans. Midlands Division. New College of Technology, Gosta Green, Birmingham 4. Fri., 10 April, 7 p.m.

Institution of Engineering Designers

NEWCASTLE UPON TYNE
"Plastics and the Engineer," by W. J. Grant. North East Branch. Northern Architectural Association's hall, 6 Higham Place, Newcastle upon Tyne 1. Mon., 13 April, 7.15 p.m.

Institution of Engineering Inspection

BIRMINGHAM
"Control and Inspection of Resistance Welding," by C. L. Railton. Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham 2. Wed., 8 April, 6.30 p.m.
BRISTOL
"Affording Quality," by F. W. Court. South Western Branch. Grand Hotel, Broad Street, Bristol 1. Tues., 7 April, 7.30 p.m.
GLASGOW
Annual General Meeting. West of Scotland Branch. St. Enoch Hotel, Glasgow. Wed., 8 April, 7.30 p.m.

Institution of Engineers-in-Charge

LONDON
"Basic Principles of Lubrication," by V. B. Harris. Caxton Hall, off Victoria Street, SW1. Wed., 15 April, 6.30 p.m.*

Institution of Heating and Ventilating Engineers

LEICESTER
Annual General Meeting and Social Evening. East Midland Branch. Grand Hotel, Leicester. Wed., 8 April, 6.30 p.m.

Institution of Locomotive Engineers

LONDON
"Vehicle Suspension and Bogie Design in Relation to Track Conditions," by R. M. Hancock. Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, SW1. Wed., 15 April, 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
"Transport on and under the Sea," by W. A. Crago and E. Norton, being the 1959 Leonardo da Vinci Lecture for pupils of grammar and public schools. Tues., 7 April, 10 a.m. and 2.45 p.m. (By invitation.)
Discussion on "What is the Present Position of the Gas Turbine Relative to the Diesel Engine for Satisfactory Stationary, Marine and Automobile Applications?" Internal Combustion Engine Group. Wed., 8 April, 6 p.m.*
James Clayton Lecture on "Some Highlights of Experience and Engineering of High-Power Heavy-Water-Modulated Nuclear Reactors," by W. B. Lewis. Fri., 10 April, 6 p.m.*
LINCOLN
"Modern Aids in the Design of Railway Bogies," by A. W. Manser. East Midlands Branch. Technical College, Lincoln. Wed., 8 April, 7.15 p.m.
SWANSEA
"Manufacture of Small Steel Castings by New Moulding Techniques," by C. B. Carter. South Wales Branch. South Wales Electricity Board's Demonstration Theatre, Kingsway, Swansea. Tues., 7 April, 6 p.m.

Instituton of Production Engineers

ACCRINGTON
"Handling and Packaging for Export," by S. C. Owen, with film. Preston Section. Accrington College of Further Education, Sandy Lane, Accrington. Wed., 8 April, 7.30 p.m.
BELFAST
"Application of Modern Production Control Techniques," by T. W. Price. Northern Ireland Section. Kensington Hotel, College Square East, Belfast. Thurs., 9 April, 7.30 p.m.

Institution of Public Health Engineers

LONDON
Discussion on "Safety Precautions in Public Health Engineering Works," opened by W. P. Cox. Caxton Hall, off Victoria Street, SW1. Mon., 6 April, 6 p.m.*

Institution of Railway Signal Engineers

LONDON
Annual General Meeting. Institution of Electrical Engineers, Savoy Place, Victoria Embankment, WC2. Thurs., 9 April, 6 p.m.*

Institution of Structural Engineers

LONDON
"The Design and Construction of the New Ship Hydrodynamic Laboratory Buildings and Tanks at Feltham, Middlesex," by A. E. Hewitt. Thurs., 9 April, 6 p.m.*
MANCHESTER
Annual General Meeting. Lancashire and Cheshire Branch. College of Science and Technology, Manchester. Wed., 8 April, 6.30 p.m.

Junior Institution of Engineers

LONDON
"Radiography and Its Application to Arc-Welded Joints," by R. F. Wilks. Fri., 10 April, 7 p.m.*

Liverpool Metallurgical Society

LIVERPOOL
Annual General Meeting. "Boron in Steel," by F. B. Pickering. Department of Metallurgy, The University, 146 Brownlow Hill, Liverpool 3. Thurs., 9 April, 7 p.m.

Newcomen Society

LONDON
"Drive to Stones in Windmills," by Rex Wailes; and "Danish Windmills," by Anders K. Jesperson. Wed., 8 April, 5.30 p.m.

Radar and Electronics Association

LONDON
"Thermonuclear Research," by Dr. T. E. Allibone. Royal Society of Arts, John Adam Street, Adelphi, WC2. Mon., 6 April, 6 p.m.*

Reinforced Concrete Association

BIRMINGHAM
"The Use of Lightweight Concrete for Reinforced-Concrete Structures," by A. Short. Midland Counties Branch. Birmingham and Midland Institute, Paradise Street, Birmingham. Tues., 14 April, 7 p.m.*

Royal Aeronautical Society

PRESTON
"The Art of Developing Aero Engines," by A. C. Lovesey. Preston Branch. Bull and Royal Hotel, Preston. Thurs., 9 April, 7.30 p.m.

Scientific Film Association

LONDON
Discussion on "Telerecording." Royal Photographic Society, 16 Princes Gate, SW7. Fri., 10 April, 7 p.m.

Society of Chemical Industry

LONDON
Spring Lecture on "Studies of the Influence of Chemical Factors on the Corrosion of Metals," by Professor W. Feitknecht. Corrosion Group. Tues., 14 April, 6.30 p.m.

Society of Instrument Technology

BIRMINGHAM
Annual General Meeting and Film Evening. Midland Section. Regent House, St. Phillip's Place, Colmore Row, Birmingham 3. Fri., 10 April, 7 p.m.
CHELTENHAM
Annual General Meeting. "Automation Behind the Iron Curtain," by J. F. Coales. Cheltenham Section. Rotunda, Cheltenham. Fri., 10 April, 7.30 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this feature should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

British Computer Society, Finsbury Court, Finsbury Pavement, London, EC2. (MONarch 6252.)
British Institution of Radio Engineers, 9 Bedford Square, London, WC1. (MUSeum 1901.)
Building Centre, 26 Store Street, London, WC1. (MUSeum 5400.)
Chemical Engineering Group, 14 Belgrave Square, London, SW1. (BELgravia 3647.)
Chemical Society, Burlington House, Piccadilly, London, W1. (REGent 0675.)
East Midlands Metallurgical Society. Apply to Mr. A. P. Blackwell, 57 Derby Lane, Derby.
Engineers' Guild, 78 Buckingham Gate, London, SW1. (ABBey 7315.)
Helicopter Association of Great Britain, 4 The Sanctuary, London, SW1. (ABBey 5160.)
Illuminating Engineering Society, 32 Victoria Street, London, SW1. (ABBey 5215.)
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London, EC3. (ROYal 8493.)
Institute of Metals, 17 Belgrave Square, London, SW1. (BELgravia 3291.)
Institution of British Agricultural Engineers, 6 Buckingham Gate, London, SW1. (TATe Gallery 8589.)
Institution of Chemical Engineers, 16 Belgrave Square, London, SW1. (BELgravia 3647.)
Institution of Civil Engineers, Great George Street, London, SW1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. (TEMple Bar 7676.)
Institution of Electronics, 78 Shaw Road, Thornham, Rochdale, Lancs. (Oldham Main 6661.)
Institution of Engineering Designers, 38 Portland Place, London, W1. (LANgham 8847.)
Institution of Engineering Inspection, 28 Victoria Street, London, SW1. (ABBey 3794.)
Institution of Engineers-in-Charge, 13 Grange Close, Edgware, Middlesex. (MILl Hill 3543.)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London, SW1. (SLOane 3158.)
Institution of Locomotive Engineers, 28 Victoria Street, London, SW1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, SW1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield Street, London, W1. (GROsvenor 5254.)
Institution of Public Health Engineers, 118 Victoria Street, London, SW1. (VICtoria 3017.)
Institution of Railway Signal Engineers. Apply to Mr. R. L. Weedon, 222 Marylevone Road, London, NW1. (AMBassador 7711.)
Institution of Structural Engineers, 11 Upper Belgrave Street, London, SW1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, SW1. (VICtoria 0786.)
Liverpool Metallurgical Society, Greenhithe, Grosvenor Road, St. Helens, Lancs. (St. Helens 5879.)
Newcomen Society, Science Museum, Exhibition Road, London, SW7. (KENsington 1793.)
Radar and Electronics Association, 83 Portland Place, London, W1. (LANgham 8183.)
Reinforced Concrete Association, 94-98 Petty France, London, SW1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton Place, London, W1. (GROsvenor 3515.)
Scientific Film Association, 3 Belgrave Square, London, SW1. (BELgravia 6188.)
Society of Chemical Industry, 14 Belgrave Square, London, SW1. (BELgravia 3681.)
Society of Instrument Technology, 20 Queen Anne Street, London, W1. (LANgham 4251.)

Metals and Materials

PRESSURELESS SINTERED BERYLLIUM

Part 2—Evaluation of a New Process

By T. R. BARRETT, B.Sc.

Atomic Weapons Research Establishment, UKAEA, Aldermaston

Beryllium satisfies many demands of the nuclear engineer for a canning, moderating and constructional material. It has a high strength-to-weight ratio and a low neutron capture cross-section, combined with high melting point and good corrosion resistance. This article, from the Atomic Weapons Research Establishment, outlines existing methods used for production of the massive metal, and especially those involving compacting and sintering. A review is presented of developments in the technique of pressureless sintering, a process which has now been established on a production basis at AWRE, Aldermaston. The first part of the article, which is being published in two successive issues of ENGINEERING, *dealt primarily with the production techniques; the second part covers development and evaluation, both of the metal and the process of pressureless sintering.*

MANY variable factors are involved in the production and sintering process; research executed in establishing the process indicates that the final result is sensitive to small variations in process control. This is not surprising when it is appreciated that the limits of powder particle size distribution are appreciably narrower in the case of pressureless sinterable powders than they are for powders compacted by the more conventional processes.

Powder production and sintering variables which have been studied include ingot composition, swarfing conditions, milling time and milling atmosphere (until recently mill charge and powder top size have been held constant), time, temperature and pressure maintained during sintering, and the effect of mould cavity shape on shrinkage. In all cases the effects of changes in these variables have been related to the extent of densification on sintering, and their relative importance assessed on this basis.

The microstructure, permeability to gases, machinability, weldability and tensile properties of the sintered metal have been studied together with its fabrication by rolling to sheet.

TABLE I—*Effect of Ingot Purity*

Origin of ingot	Density, pressureless sintered		Impurity content, per cent	
	G per cu. cm	Per cent	BeO	Fe
British electrolytic flake	1·83	99·2	0·64	0·11
Mg-reduced pebble metal	1·81	98·0	—	—
Recycled scrap	1·82	98·7	0·80	0·20
Recycled scrap	1·70	92·2	1·10	0·06
French electrolytic flake	1·83	99·2	0·25	0·03

It has been established that, within reasonable limits, the purity of the ingot metal is not critical. Good quality powder has been produced from a wide range of beryllium metals, the results being illustrated in Table I.

Control of ingot swarfing conditions is important. The powder quality is independent of the atmosphere within the lathe box but is markedly dependent on the cutting conditions (speed, feed and cut). Some batches of swarf produced by employing non-standard cutting conditions while not producing satisfactory powder on being milled for the usual time, can be made to produce good powder by milling for a different time, but with some non-standard batches it has not been found possible to produce a good quality powder under any circumstances. The results of such experiments are given in Tables II and III.

These facts are attributed to the dependence of the milling characteristics and ultimate powder particle size distribution on the shape and degree of embrittlement of the swarf particles.

As anticipated, one of the most important factors is milling time. Generally, as the milling time is increased, the sintered density rises to a maximum and then slowly falls. Experimental results are quoted in Table IV.

The results arise from differences in particle size distributions being related to different milling times. Size analyses by photo-sedimentation has substantiated this conclusion. It was from these results that the optimum times of 6 hr and 20 min were selected for conventional and high speed milling, respectively.

The effect of milling atmosphere was studied by loading the mill with standard swarf in atmospheres of purified argon, standard bottle argon, nitrogen and air. It was found that powder produced by milling in air sintered to 88·5 per cent theoretical density, in bottle argon to 93·5 per cent density, in bottle nitrogen to 94·5 per cent density and in purified argon to 98·5 per cent density.

In spite of the use of stainless steel mills, the iron contamination of the powder is low. It has been found that when a new mill is brought into service the iron contamination during the first and second run is high, but thereafter it is negligible due to the working surfaces within the mill becoming impregnated with beryllium.

With respect to the sintering variables it has been established that a vacuum below 10 microns results in the greatest densification, while pressures above approximately 10 mm of argon markedly reduce the extent of sintering. Hausner and Pinto have reported[1] that argon

TABLE II—*Effects of Cutting and Milling Conditions on Sinter Density*

Swarf batch	Cutting conditions			Swarf size	High speed milling 20 min		Normal milling 6 hr
	Speed, r.p.m.	Cut, thou'	Feed, thou'		Recovery — 200 mesh, per cent	Pressureless sinter density, per cent	Pressureless sinter density, per cent
A	160	60	2·3	Fine	—	—	55·0
B	160	60	4·7	Medium	—	98·0	96·3
C	160	—	—	Coarse	—	—	65·0
D	160	60	7·3	Coarse	38·7	87·0	—
E	160	30	4·7	Fine	39·4	86·5	—
F	254	60	4·7	—	42·3	90·5	—

TABLE III—*Properties of Sinter Achieved from "Unsatisfactory" Swarf*

Swarf A, normal milling time, hr	Density pressureless sintered, per cent	Green density, pressed at 80 tons per sq. in, per cent	Density pressed and sintered per cent
3	57·0	—	—
4½	53·0	—	—
6	55·0	—	—
9	52·0	83·4	82·7
15	50·0	—	—

TABLE IV—*Further Analysis of Effects of Milling Conditions on Sinter Density*

Material	Mill	Milling time	Recovery — 200 mesh, per cent	Density, per cent	
				Pressureless sintered	Pressed at 80 ton per sq. in
Swarf G	Normal	5 hr	44·5	82·1	—
"	"	6 "	48·0	98·9	—
"	"	7 "	56·1	96·2	—
"	"	8 "	63·0	92·2	—
Swarf B	"	5½ "	42·0	98·0	98·8
"	"	6 "	42·6	96·3	99·5
"	"	7 "	44·5	97·0	98·2
"	High speed	15 min	35·4	92·6	99·4
"	"	20 "	43·5	98·0	99·9
+ 200 H	"	15 "	—	95·6	—
"	"	20 "	—	95·9	—
"	"	25 "	—	93·8	—
+ 200 J	"	15 "	—	90·0	—
"	"	20 "	—	90·0	—
"	"	25 "	—	84·1	—

Continuing Metals and Materials

sintering of pressed compacts also adversely affects the mechanical properties of the metal. A survey of time and temperature of sintering has yielded the results quoted in Table V, from which the optimum conditions of 6 hr at 1,200° C were selected.

TABLE V.—*Effect of Sintering Temperature*

Sintering time, hr	Density, per cent					
	Sintering temperature, °C					
	1,100	1,125	1,150	1,175	1,200	1,225
4	—	—	79·6	90·4	95·6	95·5
6	65·5	76·7	87·2	90·7	96·6	97·0
8	—	—	86·1	91·7	96·3	—
12	—	—	—	92·2	97·6	97·9

The sintered component, with a volume of half that of the mould cavity, faithfully retains the shape of the cavity provided that shrinkage in any direction is not restricted. Very little reaction occurs between the beryllium and the mould because the powder commences to sinter and shrink away from the walls of the mould at a temperature below that at which the beryllium carbide forming reaction becomes evident, and also because the base of the cavity becomes coated with a hard layer of beryllium carbide, which prevents further reaction. As a result, the necessity of a mould dressing is avoided and the sintered metal has a good surface quality.

Difficulties arise in the sintering of hollow shapes on a graphite core because of the interference of the core on the powder shrinkage. The extent and results of this interference are dependent on the shape and dimensions of the hollow component being sintered. Dependent on core design the effect is either to restrict full shrinkage (with a resultant loss of density) or to permit full densification at the expense of tear formation. This latter possibility can be aggravated by local reaction with the core. These facts are best illustrated by considering the sintering of tubes. The shrinkage resulting from the sintering of a tube can be resolved

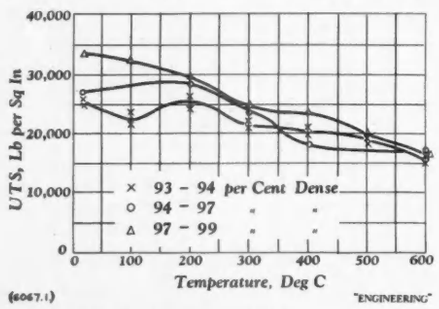


Fig. 9 Tensile strength against temperature of pressureless sintered beryllium as a function of density.

into three components—a longitudinal, a radial and a circumferential shrinkage. The sum effect of the radial and circumferential components determines whether the tube will tighten on to the core. If this happens, it results in either a reduction in density or in the formation of a longitudinal crack. The longitudinal component will also suffer interference due to the tube gripping the core over its length—this results again in a reduction of density or the formation of a transverse crack. It has been established experimentally that the extent of these effects is dependent on the ratio of the internal and external diameters, and on the length of the tube. The former effects have been studied by sintering short tubes (such that longitudinal shrinkage would be negligible) of varying ID : OD ratios. The results of these experiments are represented in Fig. 7.

These results are of particular significance regarding the production of fuel elements by sintering loose beryllium powder directly around a uranium ceramic fuel core. The wall thickness of the beryllium must be related to the diameter of the fuel rod. In addition the restriction on overall length must be appreciated.

Properties of Pressureless Sintered Beryllium

Fig. 8 shows the typical fine, equi-axed grain structure of high density metal prepared by the AWRE technique.

The permeability of 99·5-100 per cent dense cold-pressed and sintered, hot extruded and pressureless sintered beryllium to hydrogen at 600° C has been shown to be negligible (less than " Magnox " at 420° C or mild steel at 600° C). Further tests have indicated that sintered metal of 93 per cent density is permeable under these conditions, the value being $1{\cdot}24 \times 10^{-4}$ cu. cm per sec per sq. cm per mm thickness.

It has been found possible to weld the pressureless sintered metal using argon-arc techniques, and it has long been appreciated both that it is the easiest form of beryllium to machine, and that the higher density material exhibits a very good machined finish.

Much interest is attached to the tensile properties of the pressureless sintered metal as a function of testing temperature and material density. The results available are illustrated graphically in Figs. 9 and 10.

Over the range 20 to 600° C the tensile strength falls slowly with increase in temperature and at all temperatures the strength is greatest with the most dense metal. The effect of the density is greatest at room temperature, and steadily diminishes as the temperature is raised. In the best case (that of 97 to 99 per cent density), the tensile strength falls from 33,500 lb per sq. in at room temperature to 16,500 lb per sq. in at 600° C.

Up to 200° C the elongation values are almost independent (at 5·0 to 7·5 per cent) of both density and temperature. Above 200° C the value rises rapidly to a peak at 400° C where

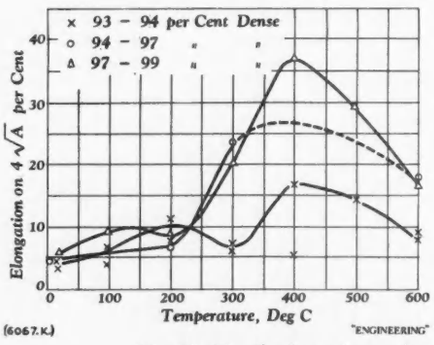


Fig. 10 Tensile elongation against temperature of pressureless sintered beryllium as a function of density.

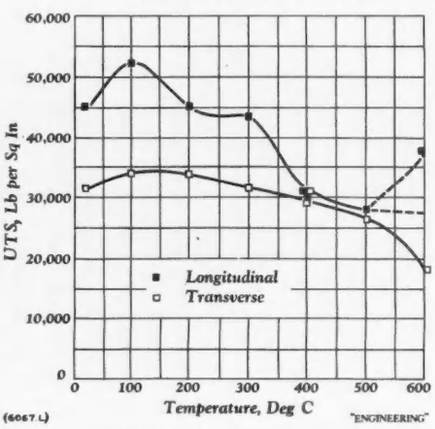


Fig. 11 Tensile strength against temperature of uni-directional rolled sheet.

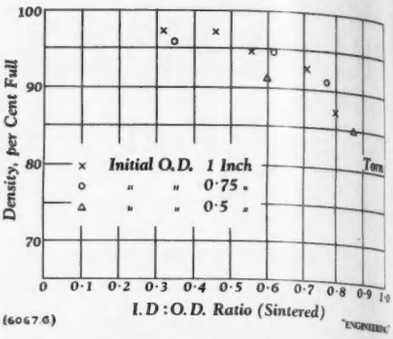


Fig. 7 Sintered densities of tubes as a function of ID : OD Ratio.

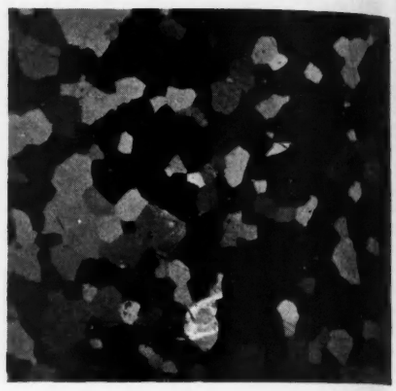


Fig. 8 Microphotograph showing the fine grain structure of pressureless sintered beryllium. × 100 polarised light.

the effect of density is most marked and where the highest density metal shows an elongation at 37 per cent.

The room temperature ductility of this pressureless sintered metal appears to be higher than that associated with other forms of unfabricated beryllium; it is higher than that for cast metal and that quoted for commercial hot pressed metal. It reaches its maximum value at 400° C in common with powder consolidated by more conventional means, but its value at this peak is greater.

Fabrication

Pressureless sintered metal exhibits good fabrication characteristics when rolled to sheet or extruded to rod or tube. These operations are performed on metal sheathed in welded mild steel containers. Consolidated powder exhibits better fabrication ability than does ingot metal, and the potential toxic hazard is less with consolidated powder than in the use of loose powder. As with other forms of the metal, the best mechanical properties are developed by fabrication, and are in the direction of working. Until recently the emphasis has been on rolling to

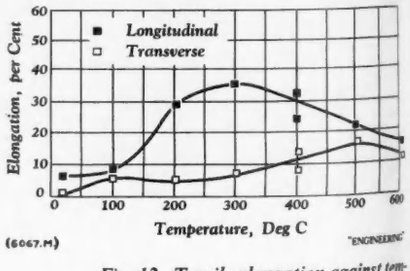


Fig. 12 Tensile elongation against temperature of uni-directional rolled sheet.

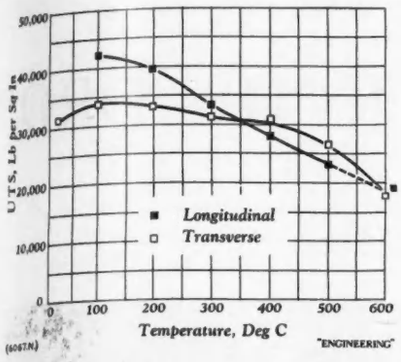


Fig. 13 Tensile strength against temperature of alternate cross rolled sheet.

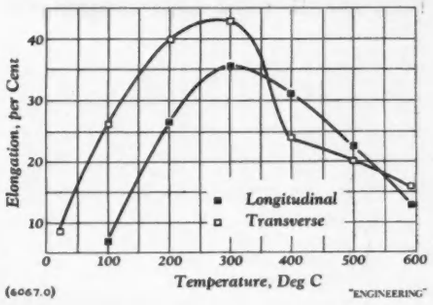


Fig. 14 Tensile elongation against temperature of alternate cross rolled sheet.

sheet rather than extrusion, and extruded sintered metal has not yet been closely examined.

The tensile properties of sheet produced by unidirectional rolling a 2 in thick slab to a $\frac{1}{8}$ in thickness with a 10 to 15 per cent reduction per pass at 1,000° C are given in Figs. 11 and 12. The strength of the material shows an overall improvement over the original sinter, this being greatest in the working direction (45,000 lb per sq. in at 20° C). The effect of working is apparent in the differences in the longitudinal and transverse ductility values. The longitudinal ductility is more attractive than the sintered metal, in that the high values occur over a wider temperature range, while the transverse ductility is inferior throughout.

The property anisotropy of sheet produced by cross rolling is illustrated in Figs. 13 and 14. The cross rolling has produced no overall improvements in strength but has reduced the strength anisotropy. The elongation values are distinctly improved, the most noticeable effect being an approximation to isotropy in the plane of the sheet and an increase in the peak ductility value to 43 per cent at 300° C.

More recent results indicate that cross rolling at 800° C results in better properties than those obtained by sheet rolling at 1,000° C. The sheet so produced exhibits a better degree of isotropy with respect to strength and ductility; the former is increased to 45,000 to 50,000 lb per sq. in at room temperature and the latter reaches a maximum of 48 to 49 per cent at 300 to 400° C. The properties of the rolled sheet in the thickness direction have not been determined. These may well be low and thus result in lack of sheet formability.

In the experience of the AWRE, cross rolled pressureless sintered metal produces sheet having both higher tensile and higher elongation values at all temperatures up to 600° C, than has sheet produced directly from ingot metal.

Conclusions

A technique termed pressureless sintering has been established for the consolidation of beryllium metal powder. By this method, loose beryllium powder of 45 to 50 per cent bulk density is consolidated to near theoretical density by vacuum sintering in an uncoated graphite mould at 1,200° C without the application of pressure.

The process exhibits many obvious advantages over the conventional methods of consolidation by cold-press sinter, warm press and hot press methods. Particular significance is attached to the possibility of the direct production of fuel elements by sintering the loose powder around a uranium oxide fuel core. This has been demonstrated on a small experimental basis. An outstanding characteristic is that pressureless sintered powder is the cheapest form of the metal which is fine grained, isotropic with respect to properties and which exhibits reasonable ductility (5 to 7 per cent elongation) at room temperature. For reactor purposes it can be used either directly in the machined condition, or after fabrication to sheet or tube. The fabricated metal has superior properties to fabricated ingot metal and appears to be slightly superior to other forms of fabricated powder metal. It thus appears that it may play a major part in any future programme of beryllium technology.

Acknowledgments

The author wishes to record his thanks to Mr. W. B. H. Lord for encouragement and advice, to Mr. G. C. Ellis for his supervision, advice and interest, to Mr. R. A. Knight for the large part he played in this work, and to Mr. E. J. Daniels for his early work in this field.

[1] Hausner and Pinto, *Trans. American Society of Metals*, vol. 43, 1951.

Construction

SHOT BLASTING HEAVY STEELWORK

Economic Preparation before Metal Spraying

A SHOT-BLASTING machine capable of handling structural girders up to 6 ft in depth by 2 ft in width, and to completely clean them so that no further touching up is required, including the stiffeners, has recently been put into commission by the Cleveland Bridge and Engineering Company Limited at their Darlington works. The machine is fully automatic and push-button controlled from one panel. Only one operator is required. There is no limit to the length of girder which can be put through the machine, but girders less than 30 ft in length have to be fed through on a special base as the main feed-roller centres are 15 ft apart.

A mixture of angular grit and round chilled iron shot is used for blasting purposes and, as the shot breaks down, it is topped up with new supplies of chilled iron round shot. The normal mixture being used is 75 per cent grit and 25 per cent new shot.

When a girder is received on to the longitudinal drive all 12 of the shot impellers are started, as are also the ancillary drives such as the shot elevators and dust-extracting fans. As the girder moves forward it cuts in turn a number of light beams which control shutters feeding the shot to the impellers. When the tail of the girder passes beyond the line of the light beams the shot feed is cut off. The speed of through-put for work requiring the superfine finish necessary for metal spraying is about 2 ft per minute. When the surface is only to be painted, the speed can be increased to between 8 and 9 ft per minute.

So far as the company know, the machine is the only one of its type in Great Britain and, possibly, in the world. When in full operation the machine requires about 400 h.p. to drive it. All the dust formed is extracted through a wet filter and the sludge removed periodically.

Girders with sections 6 ft deep by 2 ft wide can be shot blasted in this machine in the Darlington works of the Cleveland Bridge and Engineering Company.

SUSPENDED SCAFFOLD CUTS COSTS

A new form of suspended scaffolding, which is said to cut scaffolding costs by as much as three-quarters, has been adopted by Wates Limited on an 18-storey contract they have in London. The scaffolding covers three storeys simultaneously. At the top is a single-storey working platform, and beneath the platform a wire-mesh skirt provides a safety wall for the two floors below the working level. Each scaffold is 10 ft long and is supported by a bracket over edge beams built into the main structure. As the building increases in height the scaffold is lifted bodily to the next floor by tower crane.

Research and Development

IMPACT OF DROPS

By R. A. COLLACOTT,

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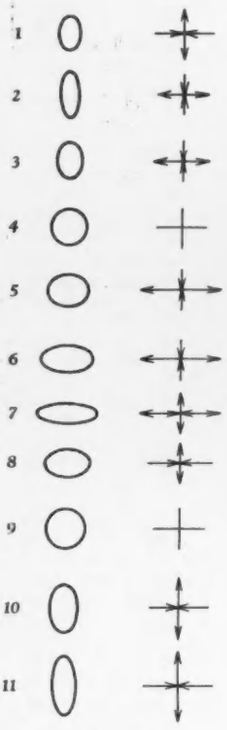
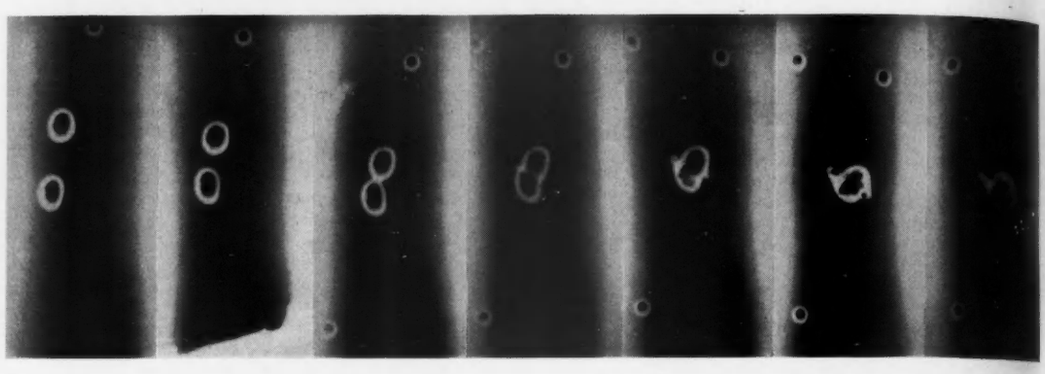


Fig. 1 Unstable oscillatory motion of the envelope of a falling drop.



THE atomisation of liquid jets and the distribution of droplets plays an important part in many combustion and allied problems. Much theoretical and practical information has been obtained on the formation of droplets under a wide range of conditions, but little or no research has been undertaken into the effect of the intermingling of two or more sprays.

In the initial stages of an investigation undertaken by the author, a number of experiments were conducted in which the pattern of a single spray was compared with that from several sprays. Most of these spray patterns showed that, at the overlap at the perimeter of the sprays, there were large concentrations of fluid, while at the centre the concentrations were similar to those from the single spray. No quantitative evidence of the drop size resulting from the spray collisions at the fringes was obtainable.

Since a number of industrial processes involve the admixture of two sprays of different substances—liquid, semi-liquid and plastic—an attempt has been made to determine the precise behaviour of drops when they collide.

Many practical factors prevent the full quantitative study of the problem and consequently an initial investigation was made in which a high-speed camera was used to photograph the behaviour of two colliding droplets. A Fastax camera running at 12,000 frames per second was focused at the estimated point of collision of two single-drop streams. Considerable difficulty was experienced in actually locating the point of impact and many runs were made with the camera before any satisfactory records were obtained.

All the several successful records showed that the same pattern of events was followed in all cases, namely:—

(1) Each droplet moved under conditions of an unstable envelope which oscillated in a regular matter as a series of elongating and contracting ellipsoids about two mutually perpendicular planes. This is indicated in Fig. 1, and is a well-known phenomenon in connection with single droplets.

(2) A small droplet known as "Plateaus spheroid" followed each major droplet. In the case of the tests carried out, this was about one-quarter the diameter of the major droplet. Each Plateaus spheroid can be seen in the series of

USING OTHER PEOPLES SATELLITES

British Observations Aid Geophysical Research

THE Royal Society have issued a report on United Kingdom observations of artificial satellites; they also outline research programmes that have developed from this work. The report sets out the contributions made and being made by various stations and indicates the type of equipment available at each. To quote from the foreword by Professor H. S. W. Massey, "There is no direction concerned with the tracking, telemetry reception and analysis of orbit data which has not been actively pursued."

At the time of Sputnik I, a committee was discussing the uses to which satellite signals could be put. Organisation was, however, sketchy. For example, the issue of predictions of satellite positions from the Nautical Almanac Office involved a major interruption of work there before more permanent arrangements could be made. Responsibility for this work was finally taken over by the Radio Research Station, Slough, in December, 1958—over a year after the first satellite was launched. But there was no delay in experimental work. The British data obtained by radio, radar, and optical methods from the initial satellites were of the first quality.

The point is made in the report that optical observations of satellites are particularly important. The accuracy required is high, and in the classification that has been drawn up on the designations vary from "qualitative"—that is, less accurate than $\pm$ 1° in position and $\pm$ 1 sec in time—to "precise"—$\pm$ 1 min in position and $\pm$ 0·01 sec in time, or better. At present, precise observations in Britain are only likely to be made by the use of kinetheodolites, all of which are held by Ministry of Supply establishments. Photoelectric equipment likely to achieve the same accuracy is under development at University College, London.

Kinetheodolites used in Britain have provided some of the most precise observations on Soviet satellites made anywhere. Orbital calculations from the data have produced significant geodetic results. Comparison of the rates of regression of the orbits of Sputnik II and Vanguard I shows that the earth's flattening at the poles is less than was previously believed, by a factor of about 1 part in 300. Variations noted in the period of revolution of several satellites suggest that there are irregularities in atmospheric density, both from day to day and over longer periods. In particular, there is evidence of a 27 day periodicity, which has been attributed to the influence of the sun.

As far as radio observations are concerned, probably the greater part of British work deals with studies of field strengths and carrier frequency. Observation of the Doppler characteristics of the transmissions enables irregularities in the ionosphere to be detected. By obtaining Doppler recordings simultaneously at several stations the need for accurate knowledge of the carrier frequency is removed. For this reason data from the Post Office Radio Station, Banbury, and Marconi's Research Laboratories, near Chelmsford, are recorded at the Admiralty Signal and Radar Establishment, Portsdown, together with the set of signals received there by themselves, and analysed in detail, using a Pegasus computer. These and similar observations will yield results of first importance for understanding the ionosphere. To encourage the concentration of observations, particular transits are designated "Key Transits" by the Prediction Service—generally two per week per satellite.

World Data Centre C, for rockets and satellites, at Slough (A and B are in Washington and Moscow) has received only a small amount of data since being set up in October, 1958. But, while contributions from WDC B, and from some European countries that have sent to WDC A have not yet been received, the report expects that "such information will be forthcoming."

Photographic Record of Disintegration

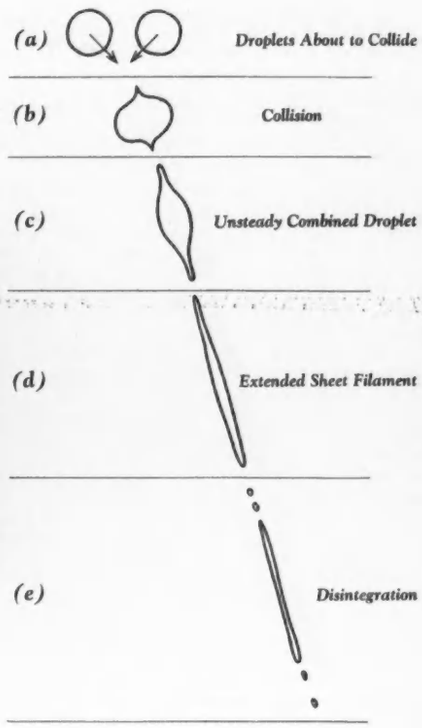
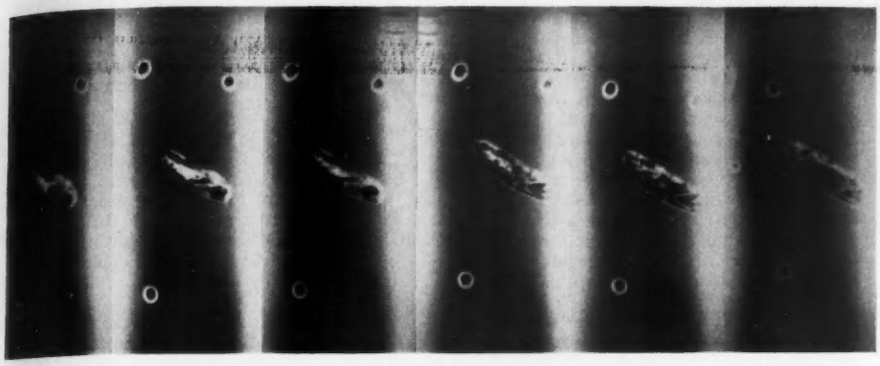


Fig. 2 Diagrammatic representation of the behaviour of a combined colliding drop.

Fig. 3 Photographic record of the collision of droplets.



photographs as it follows the major droplet, Fig. 3. Although it is described as a spheroid, each Plateaus spheroid was in fact a portion of fluid contained in an envelope which oscillated in much the same manner as the major droplet. (3) When the major droplets collided as a result of a "dead hit" there was initially an apparent union of the two droplets. This was a very unstable condition and the combined droplet then elongated in the plane of collision. There was no evidence of any oscillatory motion and the elongation continued until the combined droplet was drawn out into a long sheet filament. This sheet filament then disintegrated into a number of very small droplets—at least 10 or 12 in number. These droplets produced by disintegration then behaved in the same oscillatory manner as the original major droplets.

(4) When a "glancing" collision occurred between two major droplets or, in one case, between a plateaus spheroid and a major droplet, the effect was for a portion of the surface to be torn from the larger droplet like a piece of skin. This extended in the form of a long membrane and then disintegrated into a number of droplets in the same manner as when a "direct hit" took place between two droplets. This effect is shown in the diagram, Fig. 2.

When these results are related to the combustion of droplets and sprays, it will be seen that the effect is to promote disintegration and thus to encourage rapid combustion. In the presence of strong currents of air, dispersion of the droplets arising from disintegration is likely to occur owing to their reduced resistance to motion and consequently their lower aerodynamic drag.

16 mm film showing the effect of these collisions may be obtained on loan from the author at Queen Mary College, London, E1.

VOYAGE TO VENUS

TRANSITION from artificial earth satellite to interplanetary space vehicle can be achieved by use of a sail; not the canvas variety, but reflecting plastics material "blown" by sunlight. The small pressure of light on the large sail area can, in time, provide the ship attached to the sail with the escape velocity needed to leave orbit. Naturally solar sailing is a trade-wind affair. Sunlight will not flow around an aerofoil in the manner called for in sailing close-hauled.

A calculation of the results that might be obtained with this technique is made in the January *Industrial Bulletin* of Arthur D. Little Incorporated, Cambridge, Mass. It is assumed that a satellite having a mass of 1,000 lb can carry a sail of similar mass. With a plastics material 0·0001 in thick, the resulting reflecting area covers about 43 acres. And when in orbit a few hundred miles above the earth such a sail will receive an average thrust of about $\frac{1}{6}$ lb —enough to produce an acceleration of 200 ft per sec per day. At this rate the escape velocity of 25,000 ft per sec can be reached in 4 months, while the time to travel to Venus and return to the orbit of the earth is less than a year.

The skill necessary to set the yacht Sceptre's spinnaker—weighing a mere 2 cwt and having an area well under an acre—suggests that it will be some time before space yachtsmen are hull down for Venus. But an attempt to make the voyage with a "conventional" probe may be made this year. In fact, the planet will be favourably situated on 8 June, and the recent lunar probes reveal a rate of improvement in rocket engineering such as to make the attempt possible. United States rockets that might make the Venusian trip are the Thor-Jupiter combination or the Atlas-Titan combination. The first might be able to carry a 20 to 500 lb payload and the second might carry a load as high as 2,000 lb. Whether these combinations are ready for interplanetary use remains to be seen. However, there is another aspect of space technology that calls for attention before such voyages are made: namely, the problem of transmitting information from the probe's instruments to earth. The Soviet lunar probe was tracked for about 373,000 miles and the American for about 406,000 miles. A large improvement over this performance is needed if successful telemetry is to be made from the vicinity of Venus, which at its nearest is some 26 million miles away.

In this connection the recent announcement of the production of a compact polonium nuclear power source, able to produce electricity for periods of several months, is of particular significance. For it was the failure of the chemical batteries rather than the length of the communication path that interrupted telemetry from the two lunar probes. A recent calculation has shown that little more than one watt transmitted power is adequate for communication from Venus, provided telemetry is not interrupted by Venusian or solar radio noise.

Noise of another sort governs the closeness of approach to target. If errors in the velocity control system of the launching rocket cause a deviation of as little as 1 ft per sec from the theoretical value, the probe will miss Venus by 25,000 miles. Even so, if the telemetry functioned throughout the flight, such a miss would be an outstanding success.

COAL-FIRED GAS TURBINE ON LOAN

The large coal-fired gas-turbine which has been developed during the past 12 years at the laboratories of the Locomotive Development Committee of Bituminous Coal Research Incorporated, USA, has been lent to the US Bureau of Mines for studies aimed at a broader use of America's coal reserves. The 4,200 h.p. turbine installation was developed to furnish engineering data for a commercial engine now being designed to power locomotives.

The Bureau plan to use the turbine in co-operative research with industry to determine changes that would qualify this type of equipment for use in stationary electric power plants. One potential application, important in America, is in generating power in arid regions of the West, since the coal-fired gas-turbine requires no water supply.

In addition to the machine itself, the Locomotive Development Committee are making available to the Bureau the technical results of the research programme, on which nearly $5½ million have been spent.

The turbine was developed by LDC through research supported by six railway companies and four coal companies as part of a broad programme to increase utilisation of bituminous coal. In particular, it was hoped to demonstrate the feasibility of a direct-fired coal-burning turbine for locomotives. The latter goal was reached when a major American railway company decided to build a commercial turbine incorporating the design features developed by LDC research.

Book Reviews

AGE OF TEXTBOOKS ON THERMODYNAMICS

Engineering Thermodynamics: Work and Heat Transfer. By G. F. C. ROGERS and Y. R. MAYHEW. *Longmans, Green and Co. Ltd., 6 and 7 Clifford Street, London, W1.* (50*s*)

In the last decade or so, the number of new textbooks on engineering thermodynamics has been prodigious, indicating a basic dissatisfaction with present-day methods of teaching it. So large has this number been that, when reviewing the well-known work by Lee and Sears, Professor A. K. Oppenheim coined the phrase that ours is, among other things, " the age of textbooks on thermodynamics." Consequently, when confronted with new additions to the already long list of textbooks, this reviewer is inclined to be very exacting in his criticism and appraisal. A mere re-writing of the same things over and over again contributes nothing to the advancement of the art of teaching the subject to students of engineering and only sows unnecessary confusion.

Not so long ago the emphasis in teaching engineering thermodynamics was placed on understanding the operation of heat engines, and the fundamental and more general aspects of the subject were dismissed swiftly and with a minimum of effort. The prevailing mood was one of making a clear and not unbiased distinction between the " highbrow," and presumably not very relevant, fundamentals, and the " real engineering contents " which received more sympathetic treatment.

The appearance of Professor J. H. Keenan's justly famous work marked the beginning of a radical change of outlook, first in the United States and now in this country. The younger generation of lecturers in thermodynamics and progressively wider industrial circles have realised that knowledge of the operation of particular devices which is not firmly based on a thorough understanding of the fundamental, physical principles of the science, however thoroughly steeped in current industrial practices, is inadequate for present needs. The contemporary rapid pace of development demands an ability to undertake design or development from first principles, which implies a concentration on fundamentals to the exclusion of some of the more applied aspects of the study.

This shift in emphasis is now gaining momentum and one can confidently predict that the artificial barrier between " thermodynamics " and " engineering thermodynamics " will be obliterated eventually.

Reduced to the barest essentials, the object in the teaching of thermodynamics should be to provide a thorough grasp of the four " laws " (zero, first, second and third) together with an ability to apply them faultlessly to problems of engineering importance and coupled with a good understanding of the thermodynamic properties of gases (real as well as perfect), liquids, and solids, as well as multiphase and chemically reacting systems.

Theoretical physicists (see for example M. Born, *Natural Philosophy of Cause and Chance*, Clarendon Press, 1949) have, of course, worked out a very rigorous (and also aesthetically elegant) system, but, unfortunately, the mathematical equipment necessary for its comprehension (in particular Carathéodory's mathematical theorem) exceeds that normally provided in engineering curricula. The reviewer thinks that a good case can be made for the inclusion of the requisite mathematical topics in the curriculum in order to enable thermodynamics to be taught on a level now associated with courses in physics, even if it means postponing the beginning of it until the second year of a three-year curriculum.

The authors of the present volume, which is written in particular for undergraduates reading mechanical engineering, clearly recognised the need for a reform and made a move in the right direction, if somewhat hesitantly and cautiously. They gave an exposition of fundamentals which is just a little ahead of present-day tastes. They did not, however, succeed in avoiding some of the traps into which it is very easy to fall unless the viewpoint of a physicist is thoroughly assimilated and consistently applied.

Only a couple of sentences are devoted to the zero law and as a result, in the treatment of the temperature concept, the distinction between empirical temperature scales, the perfect-gas and the international and thermodynamic scales has not been clearly drawn. The authors have made a commendable attempt to define the absolute thermodynamic temperature scale without reference to the properties of any substance, having based it on the properties of reversible cycles. They did not, however, impress on the student, except for a brief mention (p. 121), that such a scale is not realisable in practice and that, therefore at some point an experimental comparison with an empirical scale (the perfect-gas scale, for example) is mandatory. In the light of this remark the statement that the perfect-gas law can be written $Pv = RT$ on the basis of experimental data is meaningless, because no way of measuring temperatures on the absolute scale T has been indicated. The succeeding argument proving that the internal energy enthalpy, and so on of a perfect gas are functions of temperature alone is, therefore also meaningless, and a vital link in the structure of the subject has been missed.

The first law is introduced by the consideration of cycles in a manner analogous to that used by J. H. Keenan. However, in the reviewer's opinion, the Born-Carathéodory method appears to be simpler, more firmly based on experimental facts, and so preferable.

Some of the definitions required in the handling of the first law are also somewhat stilted. In particular, the definition of heat as " ' something ' which appears at the boundary when a system changes its state due to a difference in temperature between the system and its surroundings " seems to exclude reversible heat transfer, that is, the transfer of heat in the limiting case when $\Delta T \rightarrow 0$. The authors nevertheless make use of this concept later as they must, in apparent violation of their own definition.

The second law is introduced in a conventional manner and the concept of entropy is obtained from the study of reversible cycles and the Clausius integral. Since, however, the authors have confined themselves to the study of systems possessing two independent properties only, the statement that $d_{rev} = du + Pdv$ posseses an integrating factor is mathematically trivial, because a Pfaffian with two independent variables always possesses an integrating denominator. The real physical meaning of the second law and of the concept of entropy can, in the reviewer's opinion, be obtained only from its most general form, when no artificial restriction on the number of independent properties is introduced.

The third law is not discussed at all, and the authors create the impression, when they write " the second law states that Q can in fact never be zero " that the former is implied in the latter.

The treatment of phase transitions lacks the unifying presence of the phase rule. The discussion of chemical reactions is very brief and only incidental, being confined to the section on dissociation following the discussion of combustion.

The preceding remarks should not be taken as criticisms of the book. They show, rather, how much remains to be done in order to raise the standards of engineering thermodynamics to the level normal in physics. It is recognised that nearly all text-books on engineering thermodynamics suffer from similar flaws and the authors must be commended in that they made a conscious, if not wholly successful, effort to present a consistent and logical exposition of fundamentals. Their avowed aim was to provide a textbook suitable for British students and in this they succeeded well. Theirs is the best available British textbook which covers the needs for a full course in thermodynamics and which takes the subject from its basic principles right down to applications, as every engineering textbook should. It has been carefully written, employs an easy and readable style, and it is obvious that a good deal of thought and effort has gone into it. Particular praise must be given to the selection of topics for discussion, their arrangement and the distribution of emphasis. One might wish to see slight changes here and there but the framework is sound and could not be materially improved other than by considerably expanding the volume. The reviewer particularly appreciates the space devoted to the treatment of open systems. The section on heat transfer includes the consideration of boundary layers and the Reynolds analogy, though the Pi-theorem is only quoted.

Introduction to Thermodynamics and Heat Transfer. By DAVID A. MOONEY. *Longmans, Green and Co. Ltd., 6 and 7 Clifford Street, London, W1.* (40*s*)

The introductory remarks to the preceding review apply to the present textbook also, except that D. A. Mooney has set himself a much more limited task. The above is an English reprint of the original which was published in the United States in 1955 and which, in turn, was a compressed version of the author's *Mechanical Engineering Thermodynamics*.

The aim of the book is to provide a short course in thermodynamics and, therefore, no complete exposition has been attempted. For example, the proof that entropy is a property has been completely omitted. Consequently, the book is unsuitable for a full university course but might be used in a technical college.

D. A. Mooney is a former student and subsequently a collaborator of J. H. Keenan, and the latter's stamp is clearly discernible in the book. The author commands a clear style and has a knack for simplification. Instead of meeting difficulties head on and resolving them, he succeeds in pushing them to the background.

One of the keys to the understanding of thermodynamics is a clear grasp of the distinction between physical quantities which are and which are not properties. This is really a mathematical concept, and implies in the former case the existence of a function of the requisite number of independent properties. In the latter case, such as with heat or work, no such function exists. Yet the author calls the former quantities " point functions " as distinct from " path functions," a term reserved for quantities which are not functions at all. Search as he may, the reviewer found no such classification of functions in any book on mathematics and must sympathise with the able student who may show a desire to treat the various subjects in the curriculum as one whole rather than a collection of unrelated items. A student can be induced to understand this vital distinction or meekly to accept it. In the present book the student is expected to do the latter. After all, if mathematics is a language then one ought to use it the way the " natives " do.

In the author's defence one must, however, hastily add that he is not alone in using this terminology or this approach to the subject.

J. KESTIN

BENEATH THE BONNET

The Motor Vehicle. By K. NEWTON and W. STEEDS. *Iliffe and Sons Limited, Dorset House, Stamford Street, London, EC1.* (45*s*)

Now in its sixth edition, this book which was first published in 1929, has been completely revised and much new material added. As the sub-title on the dust jacket indicates, it is written for the student, draughtsman and owner-driver. As a descriptive work, simply explaining motor vehicle engine and transmission design and construction, it is undoubtedly a worthwhile book. It should not be regarded as a design handbook, however, since mathematical analyses of the various mechanisms described are avoided.

The book is divided into three sections: "Fundamentals," "The Engine" and "Transmission." The first section briefly covers engineering drawing and principles of mechanics. Bearings and gearing are also covered in this section, the whole being dealt with in a simple manner and avoiding the use of technical language and mathematics.

In part two, entitled "The Engine," the authors have covered the whole field, again in an easily understandable manner. Dealing first with the general principles of heat engines, engine balance and construction are then covered with short descriptions of all the major components, their purpose, and the various design solutions produced over the years. A separate chapter is devoted to six and eight-cylinder engines, special and unusual designs being covered in a further chapter. Compression-ignition and two-stroke engines have chapters to themselves, in which most of the popular designs are described, together with a simple explanation of the compression-ignition principle. Further chapters cover fuels, air cleaning, carburation, lubrication and cooling. From the viewpoint of the student this part of the book could well be improved by an indication of the loads borne by the various components and how these are calculated.

"Transmission" is the title of part three of the book and covers the whole of the rest of the motor vehicle. The more usual layouts of the power transmitting components are described and further chapters are devoted to the various units. Clutches are covered in a separate chapter, friction, electric and hydraulic types being described. Gearboxes are fully dealt with in four chapters; in the first the requirements are set out, in the next chapter constructional arrangements of various gearboxes are described, including synchromesh mechanisms and the more popular of the overdrive systems. Epicyclic and pre-selector gearboxes are given a chapter to themselves; the fourth chapter being devoted to torque convertors and automatic transmissions. Much new work is reported in these chapters, the last being specially written for the sixth edition and among the new developments covered is a description of the new Chevrolet "Turboglide" transmission. Universal joint theory and a description of the popular designs, form a chapter which also includes short descriptions of several of the constant velocity joints now in use.

Rear and driving axles arrangements and problems occupy four chapters, one of these being devoted to differentials, and another to double-reduction axles. Brakes and servo systems for brake operation are then dealt with in two chapters, which cover most of the systems in use.

Front suspension, steering, and independent suspension are covered in two rather brief chapters and more space might fairly have been given to these important sections, which are somewhat summarily dealt with. The same criticisms can fairly be made regarding frame construction, with only three pages devoted to it, compared with some 300 pages on engines. Wheels and tyres and their construction are mentioned in passing; since they do not normally come within the province of general design, this is probably justified.

There is no bibliography as such; the reader's attention is, however, drawn to many works of reference in the text, which is probably more in keeping with the aims of the book. The index provided is adequate. Among the new material added to this sixth edition are notes on multi-barrel carburettors, free-piston engines, gas turbines and over-drives. Automatic gearboxes are now more fully described. This work continues to provide a convenient means of reference, of a semi-technical nature, for the student and enthusiastic driver. While unpretentious in its aims, it nevertheless performs a valuable function.

J. WYER

TRADE PUBLICATIONS

Plant

Soil Consolidator.—SOILTEST INC., 4711 West North Avenue, Chicago 39, Ill., USA. "Levermatic" soil consolidation apparatus and weigh set, to determine soil settlements. Bench model in aluminium. Also heavier models and accessories. Leaflet.

Marine Filters. AUTO-KLEAN STRAINERS LTD., Lascar Works, Hounslow, Middlesex. Brochure "Auto-Klean in Marine Engineering" describes the general design of the firm's strainers and filters and their particular use in the marine sphere.

Gas-Fired Furnace. INCANDESCENT HEAT LTD., Cornwall Road, Smethwick, Birmingham. Standard size range of gas-fired furnaces, with work chambers from 12 in by 12 in by 9in high, to 48 in by 36 in by 18 in high. Leaflet V26a.

Valves and Strainers. FILTRATION AND VALVES LTD., Endurance Works, Maypole Fields, Cradley, Staffs. VeeBee hand and motorised valves, strainers, filters, etc. Catalogue.

Boiler Feed Regulator. G. & J. WEIR LTD., Cathcart, Glasgow, S4. "Robot" two element boiler feed regulator relating feed to both water level and steam demand. Illustrated leaflet No. 172.

Filling Valve. W. S. BARRON & SON LTD., Bristol Road, Gloucester. The "Sureseal" valve for bag filling plant; 6 in opening, dust tight with local or remote control by manual or electric air valves. Leaflet.

Oil Expeller. ROSE, DOWNS & THOMPSON LTD., Old Foundry, Hull. The D type Maxoil-Duplex oil expeller; capacity from 10 to 20 tons per day depending on the seed being pressed. Residual oil in cake less than 4 per cent. Two kettle sizes. Leaflet No. 1003.

The Reviewers

Professor J. Kestin is at present working in the mechanical engineering department, City and Guilds College, University of London. He is professor of engineering at Brown University, Rhode Island, USA, and was formerly head of the department of mechanical engineering, Polish University College, London. He holds a Dipl. Ing. in mechanical engineering of the Engineering University, Warsaw, a Ph.D. in engineering of the University of London, a D.I.C., and an M.A. of Brown University. He is an M.I.Mech.E. and a Member of the American Society of Mechanical Engineers. Professor Kestin has also received the Water Arbitration Prize of the Institution of Mechanical Engineers, is co-editor of the *Journal of Applied Mechanics*, and is the United States Delegate to the International Commission on Steam Properties.

Mr. J. Wyer is general manager and technical director of Aston Martin Lagonda Limited.

On the Shelf

By Frank H. Smith

One hears vague rumours of firms conducting research into what people read what, why they read it, how closely they read it, how often they read it and so on. Not many of the findings reach the light of day—only the dim half light enjoyed by market research organisations and publicity offices, and so on. But in *Discovery* for March there is an article under the strangely uninformative title of "The Science of Science." Christopher Scott, the author, has evidently decided that this was a little too whimsical and has added the sub-title "What Scientists read and why." He explains how his results were obtained and I suppose some people will take them as representative and true to type. For myself, I have a great mistrust of this kind of statistic. Figure-jugglers take a great delight in making numbers mean what they want them to mean—rather like Alice's words—and the average person who took the trouble to learn the 26 letters of the alphabet is all too easily fooled by those who could be bothered only to learn the 10 figures from 1 to zero.

I have a leaflet from the United States Atomic Energy Commission, Washington 25, advertising "Selections from *Nuclear Science Abstracts* of special interest to engineering and industrial organisations." I mention this because I'm supposed to (you get them from Office of Technical Services) but when it gets to the point that they have to distil from abstracts I feel that things are going too far. It's that silly digest of digests all over again. Or why is honey so good for you? Because it is predigested and needs no digestion. But why does your digestion need a holiday? Because it's had too much food pumped into it—you've been a glutton. The parallel does not go that far because digests of literature are equivalent to forced feeding and one only needs that (*a*) if one is on hunger strike or (*b*) because one is too ill to take nourishment naturally.

C. Truesdell, the editor of *Archive for Rational Mechanics and Analysis*, contributes the special article in *Applied Mechanics Reviews* for February. It is "The rational mechanics of materials—past, present, future," and it has a queer bibliography. The first half is conventional and runs to 27 items. After that he gives "Sources" in chronological order. I notice he refers to Todhunter and Pearson's *History of the Theory of Elasticity and of the Strength of Materials*, an 1886 CUP work which is now out of print.

There are few of you old enough to connect Veritas with gas mantles but it comes to my mind as I inform you that the British Central Office of Bureau Veritas (International Register for the Classification of Shipping and Aircraft) will have available, in April, the English edition of the Bureau Rules 1958. Immediately available is Chapter 18 in a smaller bound edition. This deals with electrical installation. Inquiries to Winchester House, Old Broad Street, London, EC2. Pity about the price—I do not know it.

An impressive booklet is the Annual Report of Engineering Foundation which, as all well-read men (and what else are *you*?) will know, is the co-operative of the US Big Four. Progress Reports are given on current projects and sponsored projects and the list of publications makes interesting and comparatively brief reading. For $2, for instance, you can have 50 copies of an 8 page folder "Do I have Engineering Aptitude." It may be a bit late for some of you, but one should suffice and you can give the other 49 to those blokes who are standing in the way of your promotion. I was intrigued by Project 131 "Nucleation and Evaporation of Metals." Never come across nucleation before except "Way up and down de nucleation, sadly I roam, dadidadida. Far from de ol' folks at home." Or perhaps it is just a fashion designer with badly-fitting dentures. "This modom is our nucleation."

Production

CHIP FORMATION IN METAL CUTTING

A Hydrodynamic Theory

By M. M. Lamm, Kharkov, USSR

THE conventional view of the process of chip formation, as propounded by Taylor, and by I. A. Time, in the USSR, regards the deformation of the chip as it leaves the parent metal to constitute a number of discrete failures of the metal along slip planes due to the intense shearing force applied by the cutting edge. This concept leaves several features of chip formation unexplained. The author proposes an alternative theory, namely a " hydrodynamic " theory, in which the metal is considered to be squeezed plastically between the face of the tool and the main body of metal being machined. The nature of this process is described, and the manner in which inconsistencies, manifest in applying the conventional theory, are avoided in the new interpretation should be clear from the following examples.

The physical nature of the cutting process has long interested machine-tool designers, and various theories have been proposed in attempts to understand it. The mechanism of chip formation, in particular, has been the subject of considerable study, and the author of the present article, a Soviet engineer, states that there are at present two fundamentally opposed concepts of the process. One, described as the theory of elemental chip formation, has been advanced by Dr. Frederick Winslow Taylor in America and Professor I. A. Time in Russia. The other, a hydrodynamic theory, in which the process of chip formation is visualised as the flow of a viscous liquid, is said to have first been formulated by the author in 1936 on the basis of work carried out by him at the Institute of Aviation, Kharkov, and has since been further developed. The following is the abstract of an article submitted to ENGINEERING in which the author outlines his conclusions. The article has been translated and abstracted by Mr. V. H. Brix, B.Sc., A.C.G.I., principal scientific officer, Ministry of Supply.

First we consider the classical example of squeezing or upsetting a cylindrical piece of metal as shown in Fig. 1. The well known barrel shape assumed under compression is due to the friction between the deformed metal and the platens or dies, I and II. It is important to note that the metal flows so that each particle moves in a given direction depending only on its position, that is, deformation is not due to displacements of discrete elements or layers. Thus, if we consider any horizontal section, points such as A, B, C, move radially, while points A1, A2, A3, etc., in different vertical sections, move different distances, and therefore move at different velocities. The resulting velocity gradients explain the orientation of fibres when metal is plastically deformed in this manner.

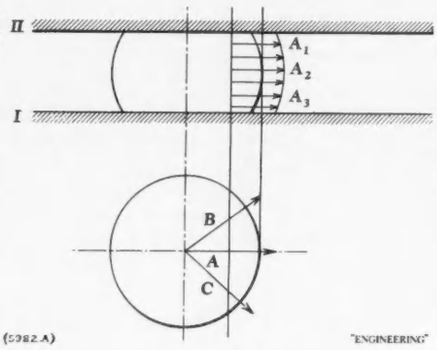


Fig. 1 Compression of metal cylinder between two parallel dies, showing velocity gradients of plastic flow.

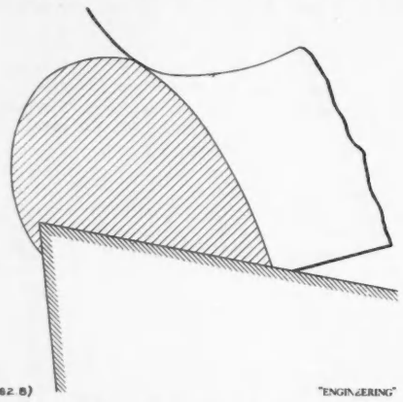


Fig. 2 Zone of plastic deformation in cutting process.

In the case of tool cutting, we regard the tool face as fulfilling the function of platen I, platen II representing some of the parent metal being machined lying outside the region in which deformation takes place. Chip formation is therefore seen to involve particle displacement of the metal throughout the whole volume concerned in the production of the chip, a different displacement occurring at each different position. For instance, in the case of the build-up edge at the tool tip, the metal is relatively static, the metal here not even attaining plastic flow, despite the fact that the stresses are high enough in themselves for this to take place.

Fig. 2 illustrates the zone of plastic deformation during a stable, that is continuous, cutting process, the shaded portion, always in front of the tool tip, representing where the plastic deformation is taking place continuously.

Now consider in greater detail what happens to the metal in this zone. Take an elementary layer lying against the front of the tool, and having a transverse cross-sectional area F. After impinging against the tip, the velocity v of the metal particles falls to v_1. But the inertia inherent in the metal tends to cause it to continue in its path parallel to the tool. Particles which are in contact with the edge lose a significant proportion of their initial velocity because of the friction against the surface, and the velocity decreases to the chip exit velocity v_c. Particles in layers farther away from the surface lose less of their initial velocity than the elementary layer considered. Thus the mean velocity at sections I, II, III, Fig. 3, decreases uniformly, and we can write $v_1 > v_2 > v_3$. Assuming continuity of flow, it follows that the cross-sections alter so that $F_1 < F_2 < F_3$. Thus particles gain a certain amount of vertical velocity, and cease to move parallel to the tool.

Fig. 4 represents a side view of an imaginary section of metal as it travels along the face of the tool. At (*a*) we assume a definite grain distribution across the general direction of cutting. We observe what happens to certain crystals, 1, 2, 3 and 4. When at stage (*b*) some slip and twinning has occurred. Grain 1 has already undergone some change in shape. So also has grain 2, but to a lesser extent. This is because the friction of the tool face reduces the velocity of the metal to the greatest extent in

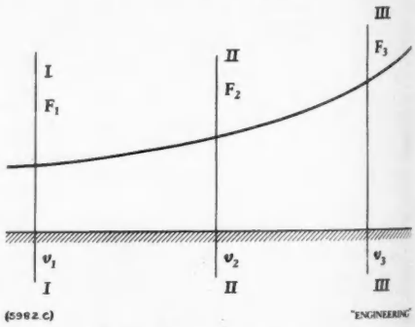
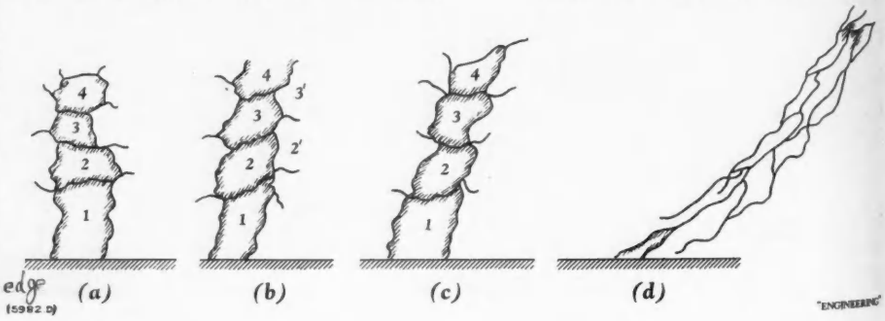


Fig. 3 Velocity of particles at various cross-sections in the metal-cutting process.

Fig. 4 Relative displacement of metallic particles along face of tool during chip formation. Motion from left to right.



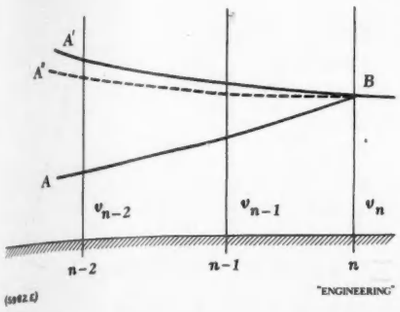


Fig. 5 Relationship between velocity and lateral "shrinkage" in cutting.

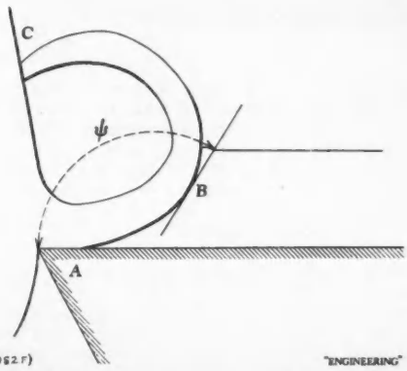


Fig. 6 Interference of workpiece and chip when using a cutting tool incorporating a chip breaker.

Fig. 7 Photomicrograph of mild steel chip taken as chip comes into contact with workpiece (see Fig. 6). Direction of chip motion is from left to right.

its immediate vicinity. Stage (*c*) shows more deformation in the grains farther away, while stage (*d*), finally, illustrates the development of a fibre or thread. The author emphasises that each individual particle of metal has its own "trajectory." Even in the case of brittle materials such as cast iron, cohesion breaks down in a disperse manner, so that metallic flow orientation will be evident. Ultimately all the particles of metal assume the constant exit velocity v_c of the chip.

We may now consider the fact that the above theory explains the chip thickness ratio changes, that is, the ratio v/v_c. Obviously, the greater the deformation in cutting, the higher this ratio becomes. High rates of deformation also involve greater heat generation in cutting, and hence lead to a reduction in the life of the tool.

The chip not only undergoes a change in thickness, but also an increase in width due to a lateral flow effect similar to the bulging of the upset cylindrical specimen referred to above.

Next consider more specifically a given case of chip formation. Assuming that chip formation ceases at a section *n*, as shown in Fig. 5, uniform chip velocity v_c prevailing everywhere to the right of *n*. At sections *n*-1, *n*-2, etc., we have velocities v_{n-1}, v_{n-2}, etc., respectively, where $v_{n-1} < v_{n-2}$, etc. Thus let curve AB represent the process of lateral "shrinkage."* We now assume that the end of the chip suddenly comes up against some stop. Velocity at section *n* now becomes zero, while the mean velocities to the left of *n* remain as they were. Particles of plastically deformed metal immediately approaching *n* undergo a sudden velocity drop from v_{n-1} to zero. This causes a sudden rise in lateral "shrinkage," which only ceases when $v_{n-1} = 0$. The same happens then at *n*-2, but, because here, v_{n-2} exceeds v_{n-1}, the "shrinkage" is greater. Finally we obtain a curve like BA′ in Fig. 5. In cases where the chip is not completely brought to rest, we obtain curves like BA″ which occupy an intermediate position between that for complete stoppage and that for

* Soviet Machine Handbook, *Spravochnik Mashinostroitelya*, gives the following definitions. Coefficient of lateral "shrinkage" $K_s = a_c/a$ where *a* is the thickness of the cut and a_c the chip thickness. The "degree" of lateral shrinkage is the inverse of this and is always less than unity.

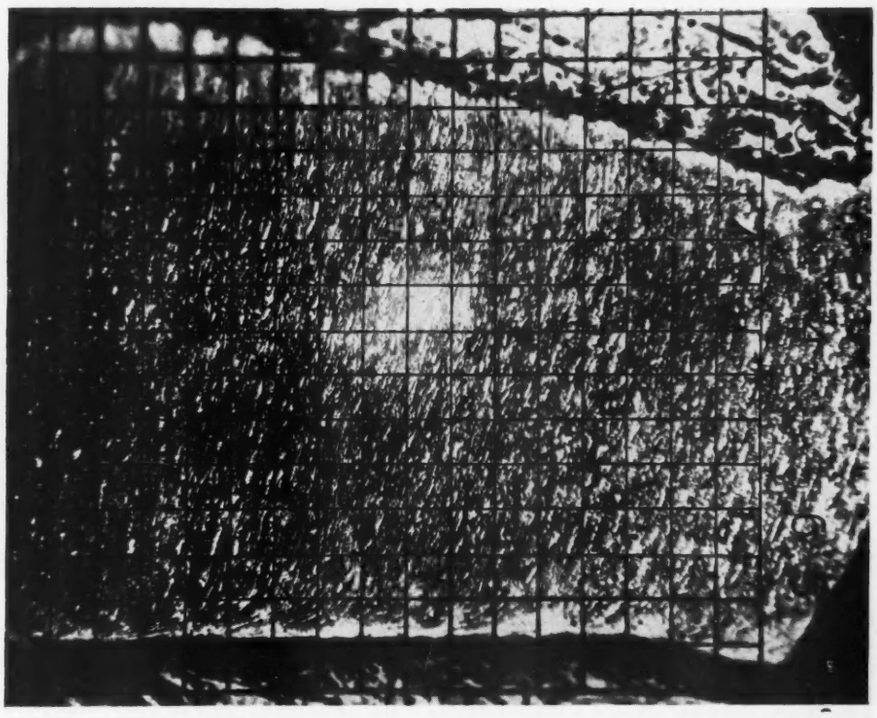


Fig. 9 Microstructure in direction of metal flow.

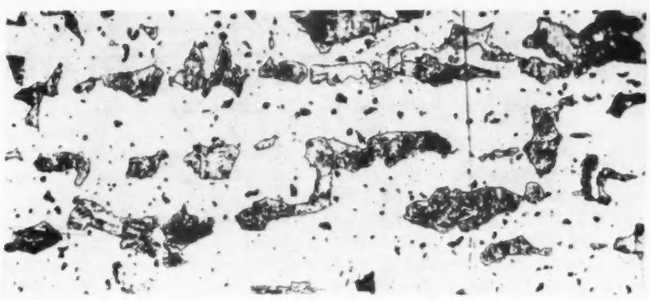


Fig. 8 Photomicrograph of soft carbon steel chip being removed by a carbide-tipped tool, showing fibre orientation as indication of plastic deformation. Chip motion from right to left.

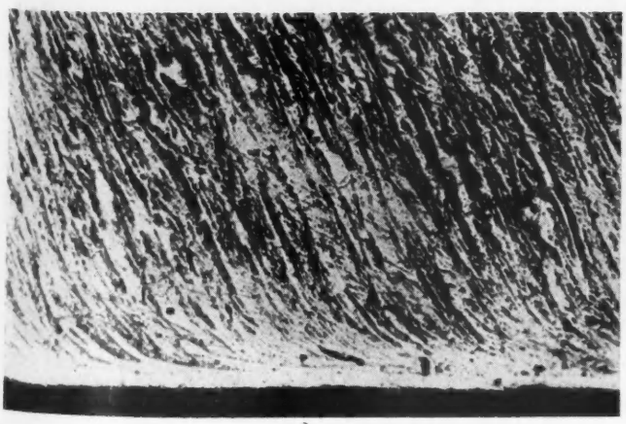
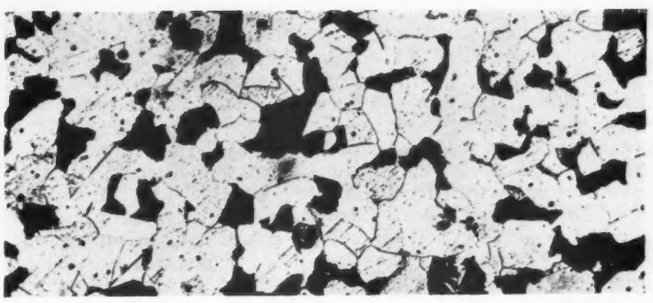


Fig. 10 Microstructure at right angles to metal flow.



Continuing **Production**

no further chip resistance beyond the tool face.

The action of a chip breaker is described as follows. While the chip moves out from B to C, Fig. 6, the " shrinkage " and thickness over AB is constant. (A represents the point at which chip formation ends.) As soon as the end of the chip C comes into contact with the workpiece the " shrinkage " begins to increase and the chip then breaks.

Fig. 7 is a photomicrograph of a chip taken at the instant when the end has come up against the workpiece. The latter was soft low-carbon steel, the tool was carbide tipped. The chip-breaker is shown in Fig. 6, where angle $\psi = 100°$. Further details: depth of cut $t = 2{\cdot}5$ mm, feed $s = 0{\cdot}25$ mm per rev, $v = 140$ m per min. Direction of motion on photograph, from left to right. The angle in plan $\phi = 60°$. (This is the angle between the projection of the cutting edge on the base plane and the direction of feed.) From these data the thickness of the cut is 0·216 mm.

Fig. 11 Microstructure of chip cut from grey cast iron by a streamlined planing tool. Chip movement from right to left.

Fig. 7 demonstrates that the minimum chip thickness is 0·84 mm and the maximum 1·08 mm. The length of the " deceleration path " is 1·1 mm while the minimum lateral " shrinkage " is 3·88 mm, the maximum 5·04 mm. There is therefore a thickening of the chip along the stretch where deceleration takes place, and a concomitant change in " shrinkage." The relatively long stretch where deceleration takes place, that is, about five times the depth of cut, shows that when the chip made contact with the workpiece its velocity was not zero, at least over the length AB (Fig. 6).

If, now, this is considered in terms of the conventional theory, we should have to assume that the velocity of the chip metal was v_c everywhere, right back to the plane or surface of shear. In this case, there would be no transitional region where plastic deformation could take place, and it would be necessary to assume a sharp and sudden velocity change.

To confirm his ideas on chip formation, the author shows a photomicrograph of a soft carbon steel chip being removed by a carbide tipped tool, Fig. 8. The cutting velocity in this case was 225 m per min, t and s were as mentioned above. The direction of chip movement is from right to left. The photograph clearly shows the fibre orientation as indicative of plastic deformation. Figs. 9 and 10 illustrate the microstructure along and transversely to the flow of the metal.

The author extends the theory to the case of brittle metals, and shows a photomicrograph of grey cast iron, Fig. 11 (cutting conditions: $t = 12$ mm, $s = 2$ mm per double stroke, $v = 5{\cdot}7$ m per min). Chip movement is from right to left. The fibrous nature of the chip metal is clear evidence of the braking effect of the tool face friction, and other factors.

The effect of too high a feed rate for a given top rake, or of too great a top rake for a given feed is for the tool to fail to develop plastic deformation right along the chip. Fig. 12 is intended to illustrate such a case, wherein the shaded zone of plastic deformation fails to reach the end of the surface of the effective face of the tool. The metal between B and C is under elastic strain only. There is therefore an enclosed volume of metal under uniform compression from all directions. As the tool advances, however, the internal compressive stresses build up and fracture of the chip takes place. The process repeats itself, cutting being resumed and taking place in a normal manner until, again, an enclosed volume of metal under compression is formed. This represents a periodic or discontinuous manner of metal cutting, similar in effect to tool vibration.

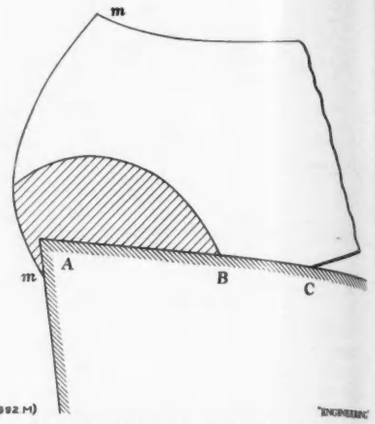


Fig. 12 Effect of too high a feed rate for a given top rake, or of too great a top rake for a given feed, showing failure to develop plastic deformation right along the tip.

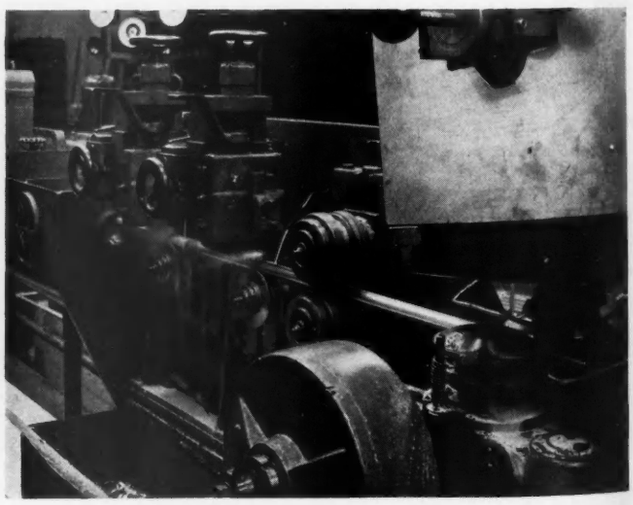
Some students of metal cutting hold that plastic flow takes place only when cutting temperatures are high enough to make the metal sufficiently ductile. Others claim that only the layer of metal immediately adjacent to the tool is plastic due to high temperature. The author's view, however, is that temperature is not the independent variable in the process, for plastic deformation can, and will take place at low temperatures. Plastic deformation, however, generates heat, and, of course, the resulting temperature will affect the ductility to a greater or lesser extent.

PRECISION WELDED ALUMINIUM TUBE

UP to the present, aluminium tubes have only been available in the United Kingdom in the seamless form drawn from extrusions, or as split type roll-formed from strip.

Elm Engineering Limited, Southern Road, Aylesbury, Bucks (a member company of the Antiference Group Limited), have installed equipment for high-frequency welding of roll-formed strip, and are now in full production. Tubes are available in a range of sizes from ½ in to 1½ in outside diameter, and with wall thicknesses from 14 to 22 s.w.g. Dimensional accuracy is equal to that required by the appropriate British Standard specification for seamless aluminium tubes.

Coiled aluminium strip is rolled to tube form in a Meer roll-forming mill, and in its almost-closed form it passes into a high-frequency welding head made by the New Rochelle Tool Corporation, New York, USA, under the trade name " Thermatool." High-frequency current (at 450,000 cycles per sec) is transmitted by means of contact shoes along the two sides of the almost-closed seam of the tube. Localised heating results, and the two edges are forced together by two pressure rollers to form a forged-type weld. Since the layer of plastic metal is only a few thousandths of an inch thick the crystal structure of the parent metal is virtually unaffected. Most of the surplus plastic metal is forced out into the external scarf, which is removed during the subsequent straightening operation. The whole operation is carried out at speeds well in excess of 200 ft per min. The weld is truly homogeneous, and the tube can be formed, shaped, pierced, polished or anodised in the normal manner.

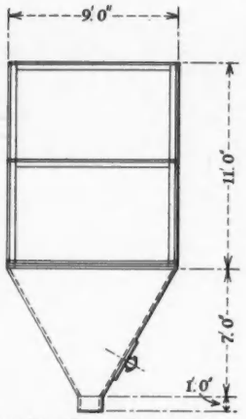


High-frequency welding after roll-forming is used by Elm Engineering Limited to produce aluminium tube at high speed.

Operation and Maintenance

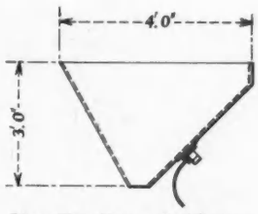
GETTING MATERIALS OUT OF HOPPERS

OF THE countless materials which industry handles in hoppers and bunkers, some have good flow characteristics and some—perhaps the majority—have quite the opposite. All too often the problem arises of getting a material out of a hopper under control, at the speed and in the quantities required. Not infrequently the problem is one of getting the material to come out at all. To make things more difficult, the behaviour of the material is not always consistent, either; it may become better or worse under the influence of many circumstances, some of which may be beyond the control of the material user. Among the materials which are consistently difficult to handle (though the degree of difficulty may vary), pride of place could perhaps be given to asbestos fibre, damp foundry moulding sand, wet boiler ash and damp pulverised fuel. With these materials and many others arching, bridging, piping and other sticking conditions are very common.

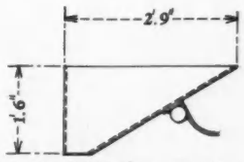


800 Watt Rotary Electric Vibrator Fitted to Large Plate Metal Hopper

(5991 A)



Piston Type Pneumatic Vibrator Fitted to Sheet Metal Hopper



Centrifugal Type Pneumatic Vibrator on Small Sheet Metal Hopper

"ENGINEERING"

Fig. 1 Typical applications of vibrators to sheet or plate hoppers.

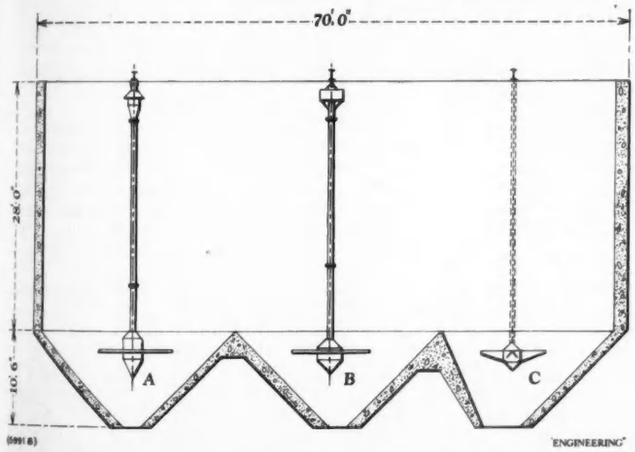
VIBRATING THE HOPPER

Good hopper design helps material flow, but as a rule this is limited in effect, and it is necessary to apply some positive force, in the form of vibration, to extract the material as required. In cases where sticking conditions vary, it may not be necessary to run the vibrating equipment continuously, but the equipment must be in place and ready to work when it is needed.

No single type of vibrator will meet all needs. Different means of applying vibration are necessary according to the nature of the material, the type of hopper or both. Other factors may have to be considered as well; transmission of vibration to a hopper structure or to some adjacent point may, for example, be undesirable, and this in turn will have some influence on the type of equipment used. Nevertheless, most requirements can be met with a relatively small range of vibrator types. Over the years the Blending Machine Company Limited, Bond Street, Birmingham, 19, have developed a range of vibrators which is capable of dealing with most hopper sticking problems. Many factors enter into the final choice of a vibrator, but it is possible to draw up general rules as a guide to the type of equipment required for specific installations.

SHEET OR PLATE HOPPERS

Where a hopper is made of sheet or plate metal (usually steel but sometimes non-ferrous to suit the material) it is a standard practice to fit a vibrator to the side of the hopper. A choice of two main types, electric or pneumatic, is available, and both are made in two forms; the electric can be electro-magnetic or of the rotary out-of-balance pattern, while the pneumatic can be either of the piston or the centrifugal type. Generally speaking, electric vibrators are initially more expensive but cheaper to run, while the pneumatic equipment has a lower first cost and higher operating expenses. With hoppers of 10 tons or more capacity the advantage usually lies with the electric vibrator on the score of running costs. For small hoppers either type can be used effectively, but the pneumatic vibrator is often chosen for its lower first cost, expecially when it does not have to operate continuously. Pneumatic vibrators are also useful where flameproof operation is important, though here again, the electric type may be applicable, certain models being available in fully approved flameproof housings. Fig. 1 shows some typical hopper applications.



(5991 B) "ENGINEERING"

Fig. 2 Three different types of immersion head units in larger type concrete bunker which could be lined throughout with Gunite or equivalent:

(A) Immersion head with vibrator fitted at bottom.

(B) Immersion head with vibrator in top unit.

(C) Universal immersion head suspended from chain.

BRICK OR CONCRETE BUNKERS

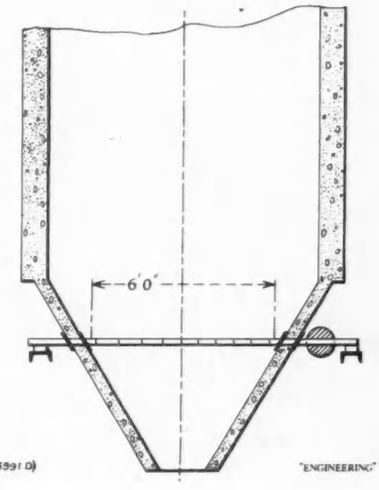
A special problem arises when bunkers are built of brick or concrete, or when they are of steel with Gunite or other special linings. In such cases, it is not possible to vibrate the bunker walls; instead, means must be found for applying the vibration to the material alone. This can be done by means of poke holes in the bunker walls through which rods or compressed air lances can be inserted, but it is obvious that such methods have their disadvantages. To obviate them, the Blending Machine Company have developed their immersion vibrators, which are suspended in the bunker. Three versions of this vibrator, which is the subject of a patent application, are currently in production. They vary principally in the means of applying the vibration at the particular point required according to the material being handled. Fig. 2 shows diagrammatically how the vibrators are installed.

In practice the immersion vibrator is suspended with its projecting arms at the arching point in the bunker, and run either continuously or on a time cycle. Little or no vibration is transmitted to the bunker walls. Considerable operating experience has shown this type of vibrator to be successful in the majority of cases, but there are a few occasions where they do not provide a proper answer to the problem.

Damp foundry sand, for example, does not respond very well to the action of an immersion vibrator, and for installations of this type a vibrating grid has been developed. As shown diagrammatically in Fig. 3, the grid is fitted horizontally a short distance above the bunker outlet. It is resiliently mounted from the bunker supporting structure or from any other convenient point other than the bunker walls themselves, which are thus free from vibration. Rubber seals are fitted at the points where the grid supports pass through the bunker walls. When it is running, continuously or on a time cycle, according to need, the grid has the dual effect of "floating" or aerating the material above it and metering material through it at a steady rate.

Most materials can be dealt with successfully by one or other of the vibrators described, or

Fig. 3 Vibrating grid situated in concrete bunker. Note external vibrator and sealing bushes.



(5991 D) "ENGINEERING"

Continuing
Operation and Maintenance

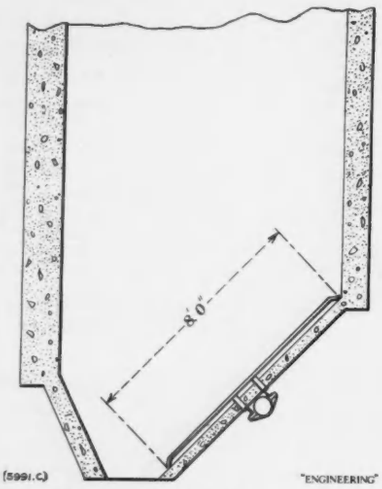


Fig. 4 Vibrating plate fitted to concrete bunker. Note external position of vibrator for easy maintenance.

probably by a combination of types, but there are still instances where the equipment, although it makes the material flow satisfactorily, does not clear the bunker sides completely. In such cases a solution is provided by a false side plate, mounted inside the bunker, and sealed and isolated from the bunker wall by anti-vibration mountings. The vibrator unit is external to the bunker, for ease of maintenance, as shown in Fig. 4. In operation the vibrator gives a directional or feeding motion to the plate inside the bunker, to feed the material down to the outlet. In most cases one of these plates effects a satisfactory clearance of the bunker sides, but in certain special circumstances two or more may be necessary.

One point common to all types of vibrator should be mentioned. In practically every case it is advisable to interlock the vibrator with the hopper or bunker outlet or the process machinery being fed with material. In this way not only are unnecessary running costs eliminated, but the possibility of compaction of the material is obviated.

REPAIR OF PLASTICS COACHWORK

The repair of glass-reinforced plastics coachwork is to be undertaken by the Automobile Plastics Company Limited, High Street, Barnet, Hertfordshire. Hitherto owners of vehicles have had to pay for complete replacement when coachwork consisting wholly or partly of glass-reinforced plastics has been damaged. The cost of replacement has been particularly high when the original mould was no longer available. Automobile Plastics have already carried out a number of repairs and are satisfied that most of the damage likely to be caused to glass-fibre laminations can be repaired quickly and cheaply without in any way weakening the main fabric. They are offering this service to both private and trade customers.

Engineering at Home

DYNAMIC PACKAGING

Two-Phase System for Pressure Dispensing

An aerosol, or pressurised pack, is not just another method of packaging, or just another sales trick; it is an innovation in packaging and dispensing. Pressurised packaging makes it possible to dispense a large variety of products efficiently, economically, and conveniently, in the form of sprays, jets, and foams. The growth of the pressurised packaging industry must have been one of the most rapid developments in recent engineering history. In the United States alone, more than 500 million pressurised packs were produced up to the end of 1957 and it is believed that by now, the total has been doubled. In the the United Kingdom, the increase has been from half a million packs produced in 1950 to 16 million in 1958.

Not only are the sales of pressure packs on the increase, but the range of application is mushrooming at a comparable rate. From humble beginnings as an insecticide dispenser for troops during the Second World War, the pressure pack has become a universal dispensing device to be found in homes, hospitals, offices and factories. The range of uses can now be numbered in hundreds, and include furniture polishes, topical anaesthetics, anti-burn sprays, sun-tan preparations, wood-worm killers, talcum powder, nasal sprays, car polishes, car paint sprays, and penetrating oils.

Although there seems to be no limit to the number of applications, it is worth noting that every pressure pack has to be specifically designed for the job in question. This means that when a new product is being considered, close attention must be paid to: possible chemical reactions between the product and the valve or container; the type of emission required—fine spray, coarse spray, foam, or jet; the stability of the product when mixed with the propellent; and, for certain medical applications such as asthma relief, the valve has to be designed to eject an accurate, predetermined dosage.

The word aerosol is a term used in colloid chemistry, and is defined in *Chamber's Technical Dictionary* as " A colloidal system, such as a mist or a fog, in which the dispersion medium is a gas." Since the word has a definite scientific meaning perhaps it is unfortunate that it has become so closely associated with this method of packaging; especially since it is only when the product has been dispensed from the container that it becomes an aerosol, and then only if the particle size is really small. Perhaps it would be better if the packages themselves were known simply as pressurised packages or pressure packs.

Most pressure packs work on a two-phase system, i.e., they consist of a single liquid or solid phase and a single vapour phase. In the case of the single solid phase it consists only of the product being dispensed. However, the liquid phase may consist of any one of the following: product alone; a mixture of product and liquid propellent; or a solution of product and propellent. The majority of pressure packs are of the second type where the liquid phase contains a mixture of product and liquid propellent.

When the liquid propellent vaporises, which it does far more readily than the product because it is a gas at n.t.p., the vapour phase created exerts its pressure not only against the walls of the container but also against the liquid phase, thereby forcing it to the top of the dip tube. When the actuator button is pressed, the liquid phase passes through the valve into the atmosphere, and continues to be propelled forward until the button is released or until the last drop of liquid gas propellent vaporises within the dispenser. The boiling point of the propellent is usually far below ambient temperature and the propellent therefore vaporises instantly upon coming into contact with the atmosphere.

The relative amounts of product and propellent in the mixture determine the nature of the resultant spray. If the amount of propellent is large, the resultant spray tends to spread out due to the smallness of the spray particles, which are light enough to become airborne. Air purifiers and most insecticides are examples of this type of spray. If the amount of product approximately equals that of propellent, the particle size becomes two or three times larger, resulting in a directional spray, or jet, such as would be required to spray paint or hair lacquer.

Foam dispenser packs make use of a three-phase system where the liquid propellent, which is normally less than 15 per cent by weight, is emulsified with the product. When the valve is actuated the emulsion is forced up the dip tube and into the atmosphere. As the emulsion comes into contact with the atmosphere, the propellent particles within it immediately vaporise, thus whipping the emulsion into a foam of innumerable particles. Toothpaste and shaving cream are examples of this type of pressure packaging.

Pressure packs are designed primarily for consumer convenience. They make possible a high standard of efficiency in consumer usage and can ensure economical use of the product. The product is completely free from the risk of contamination when the package is not in use and, when required, the product is available at the press of a button.

Some of the major advantages are specific to a particular product. For instance, in the case of a pressure pack for re-touching paint, a better finish can be obtained than would normally be possible by brushing, and there is no need to stir the paint, and no bother with cleaning the brush afterwards. Paint removing can also be improved with the pressure pack. The main advantages of applying paint remover in this fashion are that application is easier and cleaner and less paint remover is required because the activity of the remover is increased by the nature of the deposit formed, which tends to hold the solvents in close contact with the paint or varnish being treated.

The future of pressure packaging for domestic use seems well assured. No doubt we can look forward to further interesting and useful applications in the future of the dispenser that is rapidly becoming indispensable.

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